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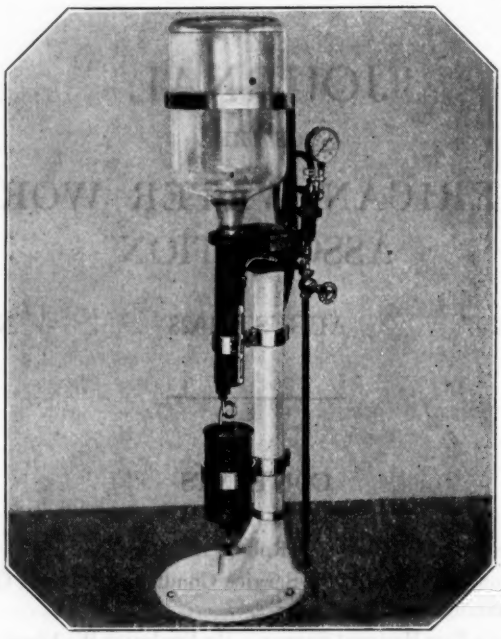

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COPPER SERVICE PIPES[1]

BY ROBERT B. MORSE[2]

Perhaps no subject provokes more discussion among men working with water distribution systems than that of the best material to be used for service pipes. Like so many other mooted questions, this one admits of no answer applicable to all cases. A water works superintendent or engineer may proclaim solemnly that service pipes of a given material outclass all others. Perhaps they do, under the circumstances with which he is particularly concerned; but along comes a champion of another material or type of construction. So it goes, until the observer, sifting the evidence and claims, concludes that conservatism, habit, and perhaps limited experience in the use of other materials, as well as truly basic local conditions, are factors in one's preference.

Service connections affect the daily life of water consumers more intimately than does any other part of the distribution system. If services are of such material that the local water reacts upon them in such manner as to become a menace to health or to cause a deficient flow by reason of progressive clogging, or in such manner that the water becomes discolored; if they leak or burst, on account of bad joints, activity of the soil or insufficient earth covering; if deposits are detached from the inside walls and clog meters, thus interfering

[1] Presented before the San Francisco Convention, June 14, 1928.

[2] Chief Engineer, Washington Suburban Sanitary District, Hyattsville, Md.

with the flow of water; or if the connections are unnecessarily expensive in construction or maintenance cost, those in charge of the system are bound to hear of the trouble. Adequacy, condition and cost of service pipe installations are prime factors in the molding of public opinion in its relation to the water purveyor. On this account, if for no other reason, it behooves the latter to consider carefully the material to be used.

Rather than to generalize too speciously on the advantages of copper pipe water services, concerning which much has been written, and thus draw perhaps too broad deductions from local experience, the writer will discuss the practice of the Washington Suburban Sanitary District and the reasons that led him to adopt the use of copper tubing for service pipes of the smaller diameters. He has not installed connections of brass, lead, galvanized steel, or of pipe lined with cement, lead or tin. With galvanized genuine wrought iron and cast iron pipe, and lately, copper tubing, available, and in view of the poor condition of galvanized steel pipe formerly locally laid, galvanized steel pipe was eliminated from consideration and there has been no sufficient reason for using brass, lead, or any lined pipe.

The Washington Suburban Sanitary District is an extensive suburban section in Maryland adjacent to the District of Columbia. This District was organized ten years ago and now has a population of about 60,000. There were approximately 50 miles of water mains and 1500 service pipes in the area in 1918. The unified system now contains roughly 250 miles of mains and nearly 11,000 water connections. Construction work is progressing rapidly and services increase in number at a rate of from 1200 to about 2000 annually.

Water furnished the District comes from a stream, at present without an impounding reservoir. Ordinary methods of rapid sand filtration and chlorination are practiced. The water is reasonably soft, having a hardness ranging from 10 to 30 parts per million. Red water troubles in connection with galvanized service pipes are prevented through the use of lime after filtration.

Soil conditions differ widely. In many sections rock of varying degrees of hardness is encountered; in others there is stiff clay, or mixtures of clay and loam or sand; in still others sand, gravel and sand, or river silt occur.

Practically all connections installed before 1918 in the water systems of the small communities of which the District was comprised

were of galvanized steel, although a few were of lead. Water supplied to these systems came mostly from driven wells. Some of the supplies had a high iron content.

During the ten years of the District's existence necessity has arisen for renewing many of the old steel connections, both on account of complaints of insufficient flow and because of grading and paving operations. These services have been in use from perhaps eight to twenty-five years. The pipes, with few exceptions, contained much clogging material and many of them had waterways so small as to be scarcely discernible. Outside surfaces, too, frequently have shown pitting and some of the pipes were so far gone that it has been impossible to thread the ends left in the ground on private premises. Many of the old services, however, still function sufficiently well to avoid a demand for replacement.

Galvanized genuine wrought iron house connections were laid exclusively during the first few years of the District's existence, and none of these pipes as yet have had to be taken out on account of deterioration. Those that have been replaced for other reasons have shown the pipe to be in practically as good condition as when laid. The writer believes, however, that the story might have differed somewhat if the same water had continued in use as was formerly served to some of the original systems acquired by the District, for the galvanized steel services in some of these systems have been found to be in a much better state of preservation than those of about the same age in others.

Some years ago the writer decided to use cast iron pipe for all service connections, except those which were to be driven under street paving. As the smallest cast iron pipe obtainable was of $1\frac{1}{4}$-inch diameter, services of this size were the smallest thereafter installed except for work under paving and under special conditions to be mentioned below. Two-inch cast iron pipe has been used where $1\frac{1}{2}$-inch connections were required.

The cast iron pipe services have been economical to install and have worked out satisfactorily from most standpoints. The larger diameter obtainable for small connections is undoubtedly of advantage in case interior incrustation takes place and it has been particularly adapted to this District's practice of providing, wherever feasible, one connection from the main as far as the property line for serving two adjacent houses. In these cases a 1-inch corporation cock with gooseneck was joined to the cast iron service pipe by a

special brass screw fitting. Where single houses were to be served the cast iron service pipe was connected to a $\frac{3}{4}$-inch corporation cock and gooseneck by a fitting of similar type.

It should be explained that all of the District services are metered and that practically all of the meters are placed between the curb and the property line in a housing approximately 4 feet in depth. Meter yokes with a cutoff on the inlet side are used and therefore curb cocks and boxes are eliminated. With both wrought iron and cast iron services the pipe rising to the inlet side of the yoke was of wrought iron. From the outlet side of the yoke or yokes in each box, galvanized wrought iron pipes extended down to the bottom of the setting and thence to the property line, from which point plumbers carried the connections into the buildings. This practice of using galvanized genuine wrought iron pipe from the meter housing to the property line is still continued even though copper tubing is employed almost exclusively for small services between the main and the meter housing. It would be hardly worth while to do otherwise because plumbers in this District almost universally install galvanized steel pipe on private property.

There has been some trouble with uneven wall thickness on the $1\frac{1}{4}$-inch cast iron pipe, but this has not been serious. The greatest objection to cast iron services of $1\frac{1}{4}$-inch diameter has arisen from breakage due to rapid settlement of freshly backfilled trenches, but even this has not been serious enough to cause much concern. This difficulty is due mostly to the writer's practice of installing water and sewer connections in the same trench, his organization having charge of the District's sewerage system as well as its water supply. The cast iron service pipes were laid on a narrow bench in the side of the sewer connection trenches and it was the practice to brace this pipe by transverse wooden struts. While some of these wooden pieces would get dislodged, with consequent breaking of the service pipe, when extremely heavy rains settled the backfill too rapidly, the increased maintenance expense caused by the comparatively few failures was much more than over-balanced by the large saving arising from the installation of the water and sewer pipes in the same ditch. Much of this trouble was avoided later on by using wrought iron pipe where soil conditions were decidedly unstable.

After a thorough consideration of the probable serviceabiltiy of copper tubing for water connections in this area and the prospect that this material, with the elimination of some of the fittings pre-

viously used, would cost at least no more for installation than $1\frac{1}{4}$-inch cast iron pipe, the writer decided somewhat more than a year ago to standardize on it for all services where $\frac{3}{4}$- and 1-inch pipe could be used. In this connection it should be stated that a considerable proportion of the connections are installed singly, as far as the meter setting, for the use of two houses and in most such cases a 1-inch pipe, if its capacity were retained, could be used in place of a $1\frac{1}{4}$-inch cast iron pipe.

The first copper tubing purchased was too hard to allow sharp bending without causing the appearance of cracks. As the mains were tapped on an angle of about 45° it was necessary to connect the tubing to the corporation cock by means of a brass $\frac{1}{8}$ bend and a brass to copper fitting. It was not possible, either, to turn the tubing up vertically so as to form a riser in the meter housing. We therefore placed a malleable iron ell, connected with the copper tubing by means of a copper to iron fitting, in the bottom of the housing and supported the meter yoke by a galvanized genuine wrought iron riser just as in the case of cast iron services.

The brass $\frac{1}{8}$ bend at the corporation cock eliminated the use of a lead gooseneck, but it proved to be a more expensive arrangement than a copper gooseneck. The necessity of installing a brass bend at the corporation cock and an iron elbow and a copper to iron fitting at the bottom of the meter housing was soon avoided through the use of soft copper tubing. All tubing except that first purchased has been of this grade. Not only has the soft tubing eliminated the need of a lead gooseneck or brass bend at the main and the fittings at the bottom of the meter housing, but it has provided a service of such flexibility that any desired deflection in line can be made without difficulty.

Our present practice is to bend the end of the copper tubing into the form of a gooseneck and to connect this end with the corporation cock by a copper to brass coupling, then to join tube lengths together with copper to copper fittings, as may be necessary to reach meter housings. At this point the copper tubing is bent to a 90° arc with radius of about 6 inches and is extended vertically in the housing up to the inlet end of the meter yoke to which connection is made by means of a copper to iron coupling. The copper riser is of sufficient rigidity to support the yoke and meter. Except as may be necessary to use up short lengths of piping, not many copper to copper fittings have to be used.

In bending the tubing use is made of a grooved wheel having a diameter of 6 inches. The tubing is held under a fixed peg and the part at which the bend is to be made is placed in the groove. By the application of pressure and the gradual slipping of the tubing backwards and forwards, the desired degree of curvature is obtained. It is possible, also, to bend the tubing by inserting it in a piece of iron pipe and gradually applying pressure on the latter. No perceptible distortion of section results from the bending process.

The flexibility of the tubing causes no trouble during transportation because the separate pieces, which are from 16 to 20 feet long, are tied together and to a length of small wrought iron pipe.

We find that copper services are particularly adaptable to installation in the same trench with sewer connections. No bench is required as in the case of cast iron and wrought iron services. It is necessary only to tamp the backfill to the required height over the sewer pipe and to wedge a few wooden sills across the trench as support for the tubing. A great many of the copper service pipes in the District have been laid in this manner and in only one case has trouble occurred. In this instance the sewer connection ditch was about 14 feet deep and the backfill very soft.

TABLE 1

Comparative costs of service piping

DIAMETER OF PIPE	PRICE IN CENTS PER LINEAL FOOT				
	Lead-A A	Copper tubing	McWane cast iron	Galvanized wrought iron	Galvanized steel
inches					
¾	35.0	14.15		10.17	6.40
1	47.5	17.70		15.31	9.11
1¼	57.5	22.36	18.33	20.48	12.32
1½	75.0	29.24		24.49	14.72
2	90.0	44.25	22.00	33.31	19.82

Where water connections must pass under improved paving we make use of an earth auger having a diameter of 2 inches and made up in sections 2 feet in length. The copper tubing is passed without difficulty through the hole made by the auger.

An approximate comparison in cost between copper tubing and some other kinds of pipe used for service connections is given in

table 1. The figures for ¾- and 1-inch copper tubing and McWane cast iron pipe represent delivered prices paid by the District this season, while those for tubing of the larger diameters, and for lead, galvanized genuine wrought iron and galvanized steel are quotations obtained for comparative purposes only. They are, however, not far different from prices that actually would have to be paid.

It is at once evident that ¾- and 1-inch copper tubing costs less than 1¼-inch cast iron and only slightly more than galvanized genuine wrought iron pipe of similar sizes. Copper tubing of 1¼-inch diameter, moreover, costs little more then either cast iron pipe or galvanized genuine wrought iron pipe of the same size; and 1½-inch copper tubing is only slightly more expensive than wrought iron pipe of the same diameter. Copper tubing of 1½-inch size, also, does not cost much more than 2-inch cast iron pipe, the diameter with which it has to be compared. While copper tubing, up to and including the 1½-inch size, is considerably more expensive than galvanized steel pipe itself, it would appear that the difference is not so great as to make it advisable to use the latter except under special circumstances, particularly as the excess cost of the tubing for services of average length would be nearly, if not quite, offset by the lower cost of laying and the elimination of the gooseneck.

When it comes to a consideration of 2-inch water connections, cast iron pipe appears to be decidediy cheaper than galvanized genuine wrought iron pipe and little if any more costly than galvanized steel. Whether a copper service of 2-inch diameter would be more or less expensive than one of cast iron, even though the tubing itself costs about twice as much per foot as the cast iron pipe, depends upon the length of the connection. It is probable that for short services the saving in eliminating the gooseneck would not be entirely offset by the additional cost of tubing and the brass fitting.

A comparison of the prices for lead pipe and copper tubing indicates that the former costs from two to nearly three times as much as the latter. When one considers, also, that lead pipe is more expensive to transport and install, on account of its weight, and requires greater skill in laying, to say nothing of its physical disadvantages, the writer sees no good reason for its use except under very special conditions.

Not a single complaint has been made about the discoloration of fixtures in this District due to the action of water on copper piping.

With the exception of the case previously noted, no copper service pipe has broken and no leak has been discovered.

While the writer has used copper service connections only of $\frac{3}{4}$- and 1-inch diameters he is favorably inclined towards installing services of this material in $1\frac{1}{4}$- and $1\frac{1}{2}$-inch sizes instead of $1\frac{1}{4}$- and 2-inch cast iron pipe. The question as to whether he will use 2-inch copper tubing instead of 2-inch cast iron pipe remains to be determined for each individual case.

SELECTION OF PUMPS TO FIT SERVICE CONDITIONS[1]

By F. G. Cunningham[2]

Often the selection of pumping equipment is based too largely upon comparison of relative prices and full load test duties without sufficiently taking into account the various collateral aspects. Adequate study of such a problem requires thorough consideration of the station as a whole and the development of a coördinated program anticipating needs for some years in the future. Such study must include estimates of all incidental uses and losses of energy in the station, and must take account of operation at fractional loads and with somewhat deteriorated duty as contrasted with operation at full load and test duty, the requirements of the pumping unit in boiler capacity, building space, operating labor, maintenance and a multitude of other considerations. Sometimes an analysis of the best division of load between units and of the actual percentage of time during which the new unit will probably operate over a period of years and an estimate of the average head and load upon the unit during its use will result in radically changing preconceived ideas. It is the purpose in this paper to touch upon some of the outstanding factors affecting decision, rather than to attempt a complete discussion.

A. HIGH SERVICE PUMPS

General considerations

Proportion of pumpage done at rates above annual average. Off-hand judgment of the most desirable size for a new pumping unit is apt to be based on an exaggerated impression of the normal capacities required in the station. A year's analysis of hourly pumping rates at Toledo demonstrates strikingly the small proportion of pumpage done at high rates. In this case with an average annual pumpage of 30 m.g.d. it was found that the rate was less than this average for 61 per cent of the time. For 33 per cent of the time it fell between 100

[1] Presented before the San Francisco Convention, June 12, 1928.

[2] Of Fuller & McClintock, Engineers, New York, N. Y.

and 150 per cent and for only 6 per cent of the time it ranged between 150 and 250 per cent of the average rate. Despite a few hourly peaks of 75 m.g.d. and the almost daily occurrence of peaks between 40 and 60 m.g.d. one 30 m.g.d. triple expansion pumping unit actually pumped over 86 per cent of the water used during the year. The writer thinks that the circumstances here were fairly representative of many cities not having high level storage reservoirs.

This analysis was particularly important in determining the size and type for an additional pumping unit. It became obvious, for example, that with a new turbine unit of 30 m.g.d. capacity to supplement the triple expansion pump, nearly all of the pumping for many years to come could be done most economically by these two base units. It was evident that peak loads of perhaps 60 m.g.d. in excess of their combined capacity could be carried by far less efficient stand-by equipment without particular effect upon the year's coal bill. This study influenced the decision to purchase a 30 m.g.d. unit instead of a 50 m.g.d. unit which would have cost more money and would have been somewhat less efficient considering combined operation with the triple pump. Since the largest unit in a station must be reckoned as out of service, the 50 m.g.d. unit would have had no advantage over the smaller one as regards increasing the reliable station capacity.

Importance of designing for fractional capacities and usual heads. The writer believes that too much stress is frequently laid upon the duty obtained under conditions of maximum head and capacity. The tendency is to fix upon a pump size adapted to a long period of future growth in demand, with a requirement that the delivery head shall equal the maximum head to be expected during this period. Compounding upon this, the pump manufacturer is apt to add some margin of pump capacity as he does not wish to take a chance upon falling short. If there be no provision in the specifications to the contrary he will also design to secure maximum efficiency at the highest head and full capacity.

Under such conditions the purchaser frequently obtains a unit which fits very poorly with his ordinary service conditions particularly during the early years. It is obvious that a pumping unit operated in parallel with others of equal size will seldom operate at full capacity and only then when the total station load happens to be a multiple of the capacity of a single pump. The usual range for most pumps probably falls between two-thirds and full capacity with

an average of perhaps 80 per cent. The usual heads will also be considerably less than the maximum.

It is quite possible particularly with centrifugal pumps driven by steam turbines to provide for the maximum heads and capacities required for short periods and for future years and at the same time so to design the unit as to give best effciency under the usual operating conditions. This is apt to produce not only a more efficient unit under average operation, but one cheaper in first cost as it may mean a smaller pump and smaller prime mover than would be used if the full load conditions were over-emphasized. One recent study of the writer's indicated a gain in duty of 10 per cent by emphasizing usual rather than extreme conditions in the design. In the specifications for this case duties at 80 per cent capacity are given double the importance of duties at full capacity, and a range of heads rather than the maximum head is set up as a design basis.

Effect of fire underwriters requirements. Where extensive high-level storage of water is not available the standard requirement of the fire underwriters is that the station must be able to carry the average rate for the maximum day, plus fire draft, with the two largest pumps out of service. Although few stations are capable of meeting this severe criterion, there is no doubt that maximum capacity should be met with at least the largest single unit out of service. This consideration coupled with the desirability of having uniform size and type of equipment and interchangeability of parts militate against stepping the sizes of the pumping units. The writer believes that it is usually best to have all of the high service units of the same size and to make that size moderate, that is, probably not exceeding the average annual demand at the time the unit is installed. This of course will vary considerably with circumstances.

Payroll costs for attendants. There is perhaps some tendency for owners of pumping stations to be over-zealous in providing fuel saving devices, using high steam pressures and temperatures and otherwise striving to secure equipment having the maximum obtainable duty. The example for this set by the large central power companies does not mean that the same reasoning applies to a water works pumping station having say only two per cent as much fuel consumption. In most water works stations the payroll exceeds the fuel cost and owners should consider carefully before installing equipment that might require an increase in the maintenance or operating personnel. A quite radical change in fair average station

conditions for example is necessary to effect an improvement in fuel economy of 10 per cent and if such improvement were obtained at the expense of adding one man to each shift there are few stations where the change would be worth while. The writer has in mind particularly one station in which the fuel cost is $30,000 per year and the operating and maintenance cost $70,000 per year. It is obvious that efforts would be misplaced in this case if spent upon reducing the smaller amount as contrasted with the larger.

Effect of high level storage. It is generally appreciated that in small cities storage of pressure water at a high elevation is decidedly advantageous and economical where it can be secured at reasonable expense. It is probable, however, that the benefits have been underestimated in the case of large cities. In a few cases as in Detroit where natural hill top elevations are not obtainable, elevated tanks are being made a conspicuous feature of distribution arrangements.

Possession of as little as one or two hours of high level storage is of decided benefit in cutting down demands upon pumps during extreme and brief hourly peaks such as come from lawn sprinkling in hot evenings. Where five or six hours high level storage plus enough to meet maximum fire draft for ten hours is available, the total pumping capacity and in some cases depending upon reservoir location the primary supply main capacity may be reduced nearly one-third as compared with having no such storage. Other benefits resulting are a much better load factor upon the station, more uniform pressures, the possibility of using simpler and less expensive arrangements to guard against breakdowns in the station and perhaps in a steam plant the elimination of the necessity for carrying a banked fire in a spare boiler. In the case of electrically driven pumps using purchased power the presence of such storage is usually almost essential and even an hour or two of storage in such case greatly simplifies the problem of starting and stopping pumps, adjusting rates and tiding over short interruptions in power supply.

It is obvious that the presence or absence of high level storage has a great deal to do with the size and type of pumping equipment and if absent the possibilities of providing such storage may well be considered where new pumping equipment is to be bought.

Electrically driven centrifugal pumps for high service

Application. Electrically driven centrifugal pumps operating as is usual on purchased power are inherently suitable for all capacities

and heads. However, their widest field of use is in stations having an average load of 300 horsepower or less, that is, where the load may be too small for an economical steam plant. For such service this type is far more widely used than its only serious competitor, the Diesel engine driven pump. The greater cost for construction, attendants and maintenance and the greater complexity for the latter type appears in most cases to have outweighed its lower energy cost.

For large stations the use of electrically driven high service pumps has been limited to places where the power rate is exceptionally low and usually also where there is sizable high level storage, a certain amount of which is almost indispensable for any station of this type. Given high level storage to absorb possible periods of power interruption and the effect of intermittent starting and stopping of some of the pumps, this type may be used in any station, regardless of size, where it proves economical. As costs of central station power are diminishing, there is reason to expect a gradual increase in the proportion of pumping plants so operated.

Design features. Practice with this type is characterized by the use of relatively smaller individual units to compensate for deficient speed control. Capacity variation is more difficult to obtain, but by reason of the usual presence of storage reservoirs is less significant than with other types. With six hours or more high level storage the pumping rate can be kept almost constant for any given twenty-four hours, except for balancing pump delivery against actual demand. Means of obtaining variation in capacity are by stepping the pump sizes, using two-speed induction motors, slip-ring motors, direct current motors, especially designed variable speed motors, throttling the discharge valves, and sometimes by installing temporarily in one unit an impeller of less than full capacity.

Where power is obtained from generators within the station and where other apparatus would not be adversely affected, the pump capacity may be regulated by varying the speed of the station generator as discussed beyond in connection with low service pump. Where practicable this is the most flexible and economical method of all.

Advantages and disadvantages of electrically driven pumps. Pumps of this type are the cheapest of all in first cost, operating labor, maintenance, and building space required. Their small cost also makes it possible readily to change the pumping arrangements as the

need develops. The commonest disadvantages are the high cost of purchased power, danger of interruptions in power supply, requiring as an offset the use of elevated storage, and lack of flexibility in speed control.

Diesel engine pumping stations

Application. The widest use for Diesel engine pumps is in stations of 50 to 400 horsepower total average load, that is, below the most advantageous load for steam stations and where electric power is expensive or not available. They are available for much larger stations, but in such cases their advantages diminish. Their relatively high cost per horsepower is disadvantageous where the average load is a small proportion of the required installed capacity.

Efficiency. The most conspicuous characteristics as to efficiency of the Diesel engine are (*a*) a remarkably high thermal duty approximating 200 million foot pounds per million b.t.u. which is greater than can be obtained with any other type of pumping equipment (*b*) this duty is nearly as good in the smallest sizes as in the largest. This superior duty is partially offset by the higher cost of oil as compared with fuels ordinarily available for a steam plant.

Methods of use. The common methods of applying Diesel engines to pumps are as follows:

a. Connection through speed increasing gears to centrifugal pumps.

b. Connection through speed reducing gears to reciprocating pumps.

c. Use of engine to drive a generator which in turn drives motor driven pumps.

d. Occasionally, direct connection of the engine to a low speed centrifugal or a high speed reciprocating pump.

The inherent difficulty in connecting the engine to the pump is in adapting speeds. The rotative speed of the Diesel engine is much too high for conventional reciprocating pumps and too low for centrifugal pumps, leading to the common use of gears or other speed changing devices.

From the standpoints of obtaining ruggedness and simplicity in mechanical design and wider competition in manufacture, the arrangement of using generators and motors between the engine and the pumps is preferable to gears. This affords also the possibility of varying the speed of the generator slightly to control the speed and

delivery of the pumps. Diesel engines may be operated under governor control and with good economy down to one-half rated speed.

Advantages and disadvantages. The outstanding advantage of Diesel engines is their high fuel economy. Diesel stations of less than 400 horsepower and with no more than moderate variation of loads are usually cheaper in construction cost than steam pumping stations. For large stations or for places where the peak load is abnormally above the average load the construction cost is usually higher than for steam stations. The design of gears for use with the Diesel engine is inherently somewhat more difficult and based upon less ample precedent than the design of gears transmitting a smoothly applied load from a steam turbine. This is not to say that good gears for such service have not been made, but the fact that they do not have the status of a widely used, uniformly satisfactory competitive product obtainable equally well from several manufacturers tends to cause hesitation in their general use.

Reciprocating steam pumping engines

Types and characters. Practically the only types of reciprocating steam pumps now bought are the horizontal cross-compound and the vertical triple-expansion pumping engines of the crank-and-flywheel type. Their outstanding characteristics are a remarkably high duty which in the case of the triple expansion pumps has not been equalled by turbine pumping units of any size, a remarkably well sustained duty throughout a long period and a wide range of capacity, low power requirement of auxiliaries, ruggedness and durability. They are suitable for steam pressures as high as 225 pounds or more and for superheat of 150 degrees without material change in the conventional design.

Efficiencies. Their actual duty under service conditions is more advantageous as compared with the steam turbine unit than would be expected from a mere comparison of full load test duties. Where superheated steam is used, the variation in duty for a range of one-half to full capacity is only 2 or 3 per cent. No such flatness of curve is possible with any other type of pumping unit. Also the auxiliaries, being attached to the main engine, are driven with a minimum expenditure of steam. With reasonable attention pumping engines sustain their duties for a long period of years better than do other types.

With steam conditions approximately as above-mentioned the overall duty of the largest cross compound pumping engine commonly made, that is about 700 horsepower, is about 185 million foot pounds per thousand pounds of steam. The largest triple pumping engine under the same conditions and of about 1700 horsepower can develop a duty of approximately 220 million foot pounds.

Application. The recent improvement in duty of steam turbine units and their compactness and low cost seem rapidly to be crowding pumping engines out of the picture. This is particularly true of the vertical triple expansion pumps which cost about twice as much per horsepower as the cross compound units and which occupy more building space without having enough higher duty to compensate.

However, there are still places where pumping engines are the logical selection, particularly where fuel costs are high and where the engine is to be operated almost continuously with a substantial load.

Sizes available. The standard patterns available for the water ends of the horizontal cross compound pumping engines limit the capacity to about 25 m.g.d. and the water pressure to about 150 pounds, subject to not exceeding about 700 horsepower which is the limit of power for the steam ends.

Vertical triple expansion pumping units may be made from standard patterns in capacities up to 40 m.g.d. and with a water pressure of 150 pounds per square inch provided the total power requirement does not exceed 1700 water horsepower.

Advantages and disadvantages of pumping engines. In competition with steam turbine centrifugal units, the outstanding advantages of the pumping engines are the high duty, the opportunity to vary the capacity widely without impairing the duty, longer life and low steam consumption for auxiliaries. The disadvantages are higher first cost, greater building space required, somewhat higher maintainence cost and the contamination of the condensed steam with oil.

Steam turbine driven pumping units

Application. Steam turbine centrifugal units are applicable, and are usually strongly competitive with other types, wherever the average station load is 400 horsepower or more, or great enough to justify construction of a steam station. Where the size of unit desired exceeds the capacity of cross-compound pumping engines or about 700 horsepower, the steam turbine unit has in most cases no

serious competitor except the electrically-driven pump with purchased power, this depending upon the presence of high level storage and the cost of power. Steam turbine units may be built in practically any desired size and may exceed by a wide margin the capacities obtainable with triple expansion pumping engines. They are commonly built now to withstand steam pressures of 300 pounds and steam temperatures of 700 degrees.

Efficiencies. Rapid advances have been made in the past few years in improving the efficiency of water works turbines and in extending the range of high grade turbines down to small sizes. With good steam conditions duties of turbine units of around 2000 horsepower, including power required for auxiliaries, approach 190 million foot pounds per thousand pounds of steam. Comparing turbine units under average load and service conditions with 700 horsepower cross-compound pumping engines and with 1700 horsepower triple-expansion pumping engines operating under equal conditions their over-all operating duties in these respective sizes may be stated to be roughly 25 per cent less than those of the pumping engines.

Auxiliaries. Usually considerable study is required to select the most advantageous auxiliaries for a turbine unit. This depends largely on securing reliability, and the most economical over-all arrangements for heating feed water, and hence upon what other equipment and auxiliaries are present in the station. Where there is a deficiency in the station in the amount of steam required for feed water heating and where such steam may not be economically obtained by bleeding from the turbines, condenser auxiliaries that are relatively wasteful of steam may be appropriately used and their exhaust steam used for feed water heating. With the reverse situation it is better to minimize as far as practicable steam consumption of the condenser auxiliaries. In either case there is a marked tendency to do away with the small reciprocating engines for auxiliary service on account of their greater need for attendance and maintenance.

B. LOW SERVICE PUMPING UNITS

Problem presented

Where necessary to install low service or secondary pumps in the same station with high service pumps the problem of securing a satisfactory and economical drive for them has usually been bother-

some. Until recently steam turbine units for such service, being small, have been of uneconomical design. Unaflow engines have been considered in a number of cases and used in a few. These give better economy than the turbines in small sizes, but are usually poorly adapted in speed to direct connection with centrifugal pumps.

In any case it is undesirable to have a multiplicity of steam driven units in a station, particularly where such units involve correspondingly numerous condenser auxiliaries. This consideration is important apart from any question of overall steam economy, as it is quite possible to run up the quantity of such apparatus to the point where an additional shift of engineers and perhaps oilers is required properly to attend to it. There are also involved the questions of maintenance and repair and of building space. These considerations have led to the endeavor to secure low service equipment having the maximum of simplicity combined with good operating economy.

Recent developments

Developments in the past few years have helped considerably to solve the problem of low service pumps. Small steam turbines are more economical and there have also come into use the practice of driving low service pumps electrically with power secured from turbo-generators either independent or mounted upon the shafts of the high service pumps, and the plan of using pressure water taken from the high service pumps to drive the low service units through direct connected water turbines.

Generators on main pump shafts

Quite a few installations of this type have been made in the past few years both with alternating current and direct current. The plan comprises placing a generator on the shaft of each main pump, carrying the power to a central board and maintaining the voltage automatically. The advisability of this plan as against having separate generators depends considerably upon the range in speed required for the high service pumps and upon the way in which the high service and electric loads concur.

For example, the night high service load might require only one pump to be run whereas the low service load coupled with other possible uses of power about the premises might be uniform throughout the twenty-four hours. If so this plan would necessitate having

each generator capable of carrying the whole load thus increasing the cost of the electric equipment.

Where the high service pump speed must be varied more than 10 per cent such installations must usually be of the direct current type and in that case may not be as desirable as having separate generators or water turbine drive. Advantages of the plan of driving generators from the shafts of the main pumps are that it increases the average load upon the main pump turbine and therefore improves the economy, and minimizes the number of steam driven units and auxiliaries. The principal disadvantages are lack of flexibility, the inability to vary the generator speed independently of the high service pump speed and some shortcoming in reliability as would be the case especially where the tripping of a single turbine might cut off the water pressure, the lights and all electric auxiliaries simultaneously.

Independent turbo-generators to supply low service power

It is often advantageous to install separate turbine driven generators, including one spare unit, to supply power to motor driven low service pumps and for other auxiliaries about the premises. In most steam stations small generators are necessary in any event. This plan amounts merely to increasing their size.

With a generator and low service motors of the AC type it is quite possible under this plan to vary the generator speed and thus to control the speed and capacity of the low service pumps within as wide a margin as is ordinarily required and to do this with practically full efficiency of the generator and motors; the flexibility in such case being substantially as good as could be secured with an independent steam drive for the low service pumps. Generator speeds can be varied as much as 10 per cent without undue effect upon the heating or economy of the generator or of any of the motors, regardless of type, driven by it. Under usual conditions a considerably wider speed range can be obtained since the decrease in speed is accompanied by a decrease in power requirement thus offsetting the tendency to overheat. With usual pump characteristics a 10 per cent speed change with constant head would vary the pump capacity 40 per cent or more. The functions of miscellaneous small motors driving auxiliaries and used for other purposes can seldom be impaired by a 10 per cent reduction in speed particularly if such conditions are anticipated at the time of their selection.

Water turbine driven low service pumps

In some cases the best method of driving low service pumps may be by means of water turbines taking water from the high service pumps and returning it to the suction well or clear water basin. In this way power is applied to the low service pump shaft with an efficiency of roughly 80 per cent of the duty developed by the high service pumping unit. Usually the duty thus obtained would be better than could be secured with any type of independent steam drive for the low service pumps and further advantages would be obtained in the simplicity of the arrangement and the little attention required by it. The method also has the effect of increasing the load and improving the duty of the high service unit. It is inherently somewhat less economical of energy than the plan of providing generators on the main pump shafts, but in most cases the difference would not be outstanding as measured in dollars per year.

This plan is subject to some limitations in securing a common speed for the low service pump and the water turbine that will be conducive to good economy for each one under the head to which it is subjected. This difficulty can be overcome by the use of reduction gears, but this increases the cost and complexity. If the water turbine is located below the level of the basin or conduit into which the tail water discharges it is necessary to use the reaction type. In other cases either an impulse or a reaction water wheel may be used.

VALUE OF A FIRE HYDRANT SURVEY

By Frederick W. Albert[1]

Fire hydrants installed in connection with the water mains in any community are of value and importance only in so far as they are available for instant use in case of need. The community has a right to insist upon the constant availability of these hydrants, especially if the water department is paid a specified amount per hydrant per year for this service. This is equally true whether the water department is privately or municipally owned and operated. In the final analysis, the citizens pay, either in the form of taxes or insurance rates, for fire protection.

If the community is fortunate in having water works officials who are educated, trained and experienced in that work, their confidence will be entire and complete, and they have a right to expect that these men will be alive to their responsibility and constant in their vigilance of the operations of their department, since it affects the welfare of the community they serve.

An appreciation of this service will sooner or later be reflected through a better understanding by the fire insurance adjustors and rate makers, who in good time will give the community the benefit of their confidence in the local water department, through a reduction in the fire insurance charges. This, in itself, should be sufficient grounds for the community to insist that regardless of the salaries required to be paid to get this class of executives, those in charge of their local water plant should be men who are capable of satisfactorily performing their duties to the ultimate benefit of the community and of these served.

Knoxville, Tennessee, for the past four years has been in the process of rehabilitating its old water works, and in the construction of a new water works supply and distribution system. This has included the building of an entirely new pumping station and filtration plant, a new ten million and a new one million gallon reinforced concrete, covered reservoirs, the laying of approximately 28 miles of trunk,

[1] Engineer in Charge of Water Department, Knoxville, Tenn.

feeder and distribution mains, the installation of many additional fire hydrants and valves, and the elimination of numerous dead-ends and mains of insufficient size. The total cost of this work, financed out of a bond issue, was $2,500,000.

The new plant has a rated capacity of 15 million gallons per day, which is considerably in excess of the average daily consumption of the city.

Within these four years the water department has conducted four fire hydrant surveys. The time set is always in the fall of the year in the hope and expectation that the survey will be completed before the advent of freezing weather, which usually hits Knoxville around the New Year. The first survey showed approximately 35 per cent of the hydrants in need of repairs, in order to make them available for service. Many of these were two hose nozzle fire hydrants, which were immediately eliminated from the system, so that now every fire hydrant installed in the City of Knoxville has a standard steamer connection, in addition to two 2½ inch hose outlets.

The last survey of the fire hydrants in Knoxville was begun on October 17, 1927, and was completed January 27, 1928. There were 1868 fire hydrants inspected. Of this number 1628 or 87.2 per cent were found in first-class condition. Seventy-one or 3.8 per cent needed minor repairs (such as oil hole screws, cap chains, or chain hooks) while 148 or 7.9 per cent were in need of major repairs (such as caps, valves, valve seats, upright valves and valve stems). A total of 21, or 1.1 per cent, were found in such condition as to call for their replacement, since they were of an old make, for which repair parts could not be obtained. All of this was found in spite of the fact that a complete survey of the fire hydrants had been made and the hydrants had been put in excellent shape not more than a year before.

Minor repairs are caused by carelessness in the removal of the caps by those who have permission to operate public fire hydrants. Major repairs are occasioned through the operation of public fire hydrants by people who do not understand their operation and who invariably employ extreme measures when cutting off or turning on the hydrants. In some cases, it has been observed that two or three men will swing on to a fire hydrant wrench, using a piece of pipe in their effort to either close or open the fire hydrant, with disastrous results to the hydrant. Of course, this can be eliminated if the fire hydrant operators are limited to the employees of the water and fire

departments. Unfortunately, however, the street and sewer departments are required to use them in connection with their work. Contractors, doing either sidewalk or street work or building structures, are also permitted to draw water through meters attached to a fire hydrant. It is largely from these two groups of men that the principal amount of damage is done to public fire hydrants.

In a number of cities this trouble has been eliminated through the installation of special connections from the main to the curb line at designated points where the street and sewer personnel are required to make their connections when getting city water for their operations. These outlets often have special hose connections, so that hose carried by the street and sewer departments are equipped with couplings to fit these special outlets. These connections will not fit the hose outlets on the fire hydrants.

In many communities contractors, either working for private interests or for the city, are prohibited from using fire hydrants, when obtaining water for their operations. Communities having this regulation, both as it affects the street and sewer departments, as well as contractors, are not troubled with the damages to fire hydrants set forth above, and as found in Knoxville, Tenn. Both systems have their advocates,—both systems have their good and bad features. Each community usually inherits the system at present in operation, which is all too frequently one which has grown up in the past without any thought of the effect upon the community as a whole.

HYDRANT SURVEY PROCEDURE

The procedure employed in a fire hydrant survey in the City of Knoxville is as follows:

The inspector, with one machinist and one laborer, is given a truck and the tools and materials needed for their operations. The city is divided into sections, beginning usually on the outskirts and working into the center of the distribution system.

Upon reaching a fire hydrant the inspector first takes his readings of the static and residual pressure. During these operations he learns whether or not the remaining caps and other parts of the hydrant are holding, or whether they need new gaskets or other repairs. With the water shut off, the steamer cap is immediately taken off, and the inspector tests the draining of the fire hydrant. If it fails to drain, it is marked for a "dig-out," or the inspector and

his men excavate around the hydrant and see that the drain holes are unstopped and a new rock nest is placed.

The stuff nut is then removed, and the packing loosened and oiled so as to provide a satisfactory cut-off of water leaking up around the stem. If, after shutting down the fire hydrant, the crew detects a constant flow, it is apparent that the valve is not properly shut. The hydrant is then opened and shut several times in the hope that any obstruction under the seat will be washed out, or if this fails to stop the leak, the fire hydrant is put out of service by closing down the valve on the lead and the interior thereof is then taken out. At this time, new valves and, if necessary, seat rings, stems and other parts are replaced as needed. These comprise the major repairs to the fire hydrants noted above.

In Knoxville the survey crew leaves the plant at 7:30 a.m. and returns at 4:30 p.m., having a half-hour for lunch.

The cost of the last fire hydrant survey amounted to 82 cents per fire hydrant inspected. The average cost of the minor and major repairs amounted to $1.60, including the 82 cents for inspection. The total cost of the survey was $1350.00. Ninety-one days of actual work were required to complete the survey. The average number of hydrants inspected and repaired per day was 20.

The operations of the survey crew, or crews, (there were two during a part of the period) were interrupted by the extremely cold weather which the City of Knoxville experienced in the early part of January, when the temperature dropped to minus 2°, the lowest level since 1917.

With the arrival of the freezing weather a number of small crews were sent throughout the distribution system to determine the condition of each fire hydrant, as experience has proven that all too frequently, even though a survey party had passed and O.K'd the hydrants, subsequent operators do not always shut off the hydrants properly, with the result that the barrel would be filled with water, through leakage of a greater flow than the drain holes can carry off.

The water department felt that the emergency required this supplementary and additional inspection for fozen fire hydrants, as it is a well known fact that, with the advent of extremely cold weather, there are more buildings burned down than at any other time of the year. It was fortunate, for the inspection developed that there were 103 frozen fire hydrants.

The department immediately put 16 small crews of 2 or 3 men each on the work of inspecting and thawing out. The inspection crews consisted of one man, each equipped with a fire hydrant wrench and a string with a lead weight on it. The inspector simply took off the steamer cap and dropped the lead weight into the barrel. Knowing the depth of the valve below the steamer outlet, the inspector could easily determine by the length of the cord dropped, whether the fire hydrant barrel was free or frozen.

The locations of the frozen fire hydrants were telephoned into the central office as soon as they were discovered. Upon receipt of this report, crews were sent out with thawing machines, or with kindling and oil, and steps were taken at once to thaw out the frozen hydrants. As a result of this work by the water department, the fire department of the city, during the ten days of this extreme cold, had very little difficulty in handling fires with its usual dispatch and success.

As the number of calls upon the fire department during this period was greater than for any similar period in recent years, the advantage and value of this survey by the water department to the property owners of the city of Knoxville may be readily appreciated.

It seems to the writer that every community of a size to justify the maintenance and operation of a water department, such as exists in Knoxville, can well afford to adopt this practice of an annual fire hydrant inspection, in view of the great saving resulting to the property.

COST ACCOUNTING FOR WATER WORKS[1]

By R. H. Smith[2]

It is very difficult to present a plan of cost accounting procedure applicable to all water companies of the state, for many cities would require an elaborate set-up of forms and accounts, while the cost of maintaining such a system would be prohibitive for the smaller companies.

Most companies have someone in their organization capable of developing a cost system in keeping with their individual needs. For this reason I shall attempt to outline to you only the advantages of cost accounting as they pertain particularly to water companies.

Regardless of what system may be used, the object of cost accounting practice is to present in comprehensive manner the results of operation, so that in the end deficiencies may be remedied and intelligent rates produced.

The organization should be divided into departments and each department into units of performance. To illustrate, there may be a department known as the Operating Department, with units of performance as follows: Pumping, Purification and Chemical Treatment, Distribution of Water, Storage, etc. A general accounting plan would probably include the costs in a single operating account, whereas, under a cost accounting plan, the expenses incident to each classification would be treated separately. For instance a general system would give you the total cost of repairs, but would not attempt to secure the cost of production of each sales unit, or divide this cost over the different processes, as a cost system would do.

To the cost per selling unit of distributed water, should be added administrative and selling expenses to arrive at the selling price. Labor and material being used in various departments in different amounts, the total amount should be allocated to the different units, or processes, which use them.

There is no question but that cost data are very valuable in all water works organizations, but care must be used in the cost accounting

[1] Presented before the Florida Section meeting, April 4, 1928.

[2] Auditor of Receipts, Utilities Commission, Orlando, Fla.

plan, so that it does not become burdensome. Its advantages should be of such a nature as to far outweigh the expense incidental to the maintaining of the additional records that would be necessary.

A good system of cost accounting will enable a manager to locate definitely excessive costs in all departments. It will serve as a means of determining rates to the consumer, as well as giving information to substantiate the need for said rates. Waste of materials and supplies would be discovered more readily by a comparison of the perpetual inventory, as shown by the store record sheets, with the physical inventory taken at intervals.

Without knowledge of your individual needs for a cost accounting system I feel it is appropriate to spend the greater amount of the time allotted to me on that part of accounting that applies more particularly to customers' accounts.

We have had an increasing number of requests for information concerning the handling of water applications, billing and other matters pertaining to water supply. I shall outline, therefore, the routine we have found best suited for the requirements in Orlando.

APPLICATION FOR SERVICE

There are two forms of application, one to meet the requirements where water service has not been previously supplied, the other for a reinstatement of an existing service and meter.

Application for the new service must supply the Construction Department with authority to lay any necessary mains, supply an individual tap, a lateral to the location of the meter, a meter box and meter. It gives authority also to the Accounting Department for setting up a ledger card for the billing of the service, as well as a meter card for the reading of the meter.

In cases where the main extension does not exceed 100 feet the following charges, to cover the expense of the Construction Department, have been established on each new installation. These charges are termed tapping fees. They are as follows:

TAP	CHARGE
inches	*dollars*
¾	9
1	12
1¼	15
1½	18
2	21

Cut-ins of greater than 2 inch capacity are handled by separate estimate, drawn by the engineering department from details secured by actual measurement at the service location.

EXTENSION ESTIMATES

It is not our practice to attempt advising the customer whether or not an extension charge will be made before accepting his application for service. When the service order is received in the Construction Department a check of our reference maps is made at the proposed location and a detailed statement of the work involved is drawn. Should the requirements be within the one hundred foot limit, these details are transferred to a regular work order, which is then forwarded to the manager for formal approval.

Estimates on extensions over one hundred feet are referred back to the Sales Department, whose representative visits the new location with a view of securing additional customers within the distance to be covered by the extension.

When the extension charges must be advanced by the customer, the representative outlines to him the following plan of handling. A confirming letter is later mailed.

The amount of money involved is deposited with the Commission and a formal agreement is drawn between the customer and the Commission, to refund the deposit in full when the revenue from the extension totals one-third of the amount deposited, within a consecutive twelve month period.

Application for an old service, or a service where tap and meter are already installed, simply authorizes the Service Department to turn on the water.

Each type of order, of course, provides customer's name, service location, mailing address, deposit number, and such like, which information is transferred to the ledger card.

HOUSE RECORD

The importance of simplifying, in every way possible, the placing of a customer's order for water service is generally recognized.

An up-to-the-minute service record, easily accessible to the clerk drawing up the order, is a first essential to this end.

Our House Record we have found to function best in a geographical arrangement by street location, the streets in alphabetical order. A service card is set up at each and every address where water service

tap and meter have been installed. Where no such installation has been made the clerk's reference to the record shows no card set up, which indicates a new service order is required. The card for such service is set up immediately the order passes from the counter to the House Record clerk.

Where reference to the record shows a card regularly set up the counter clerk issues a re-instatement or old service order.

To insure prompt handling of the order, it is a fixed rule the counter clerk must refer to the street location, as given by the customer, before entering his order. This serves as definite protection against confusion in street name, number, and type of order to be entered.

ORDER ROUTINE

The completed order, in triplicate, passes from the counter clerk to the House Record clerk, where the order number, customer's name, meter number, and other detail is recorded on the card at that location. They are then listed on a typewritten recap sheet and forwarded to the Credit Department. The third, or file copy, is placed in numerical order on a board file, for follow up. After receiving formal credit approval, the second, or work copy, is forwarded, together with recap sheet, to the Service Department. The Original, or Contract copy, is forwarded to the General Manager for signature, thence back to the Sales Department for filing.

The order numbers, as listed on the recap sheet, are checked by the Service Department clerk as the work order copies are received. The recap sheet is then receipted and returned to the Sales Department.

Completed work orders are returned directly to the Accounting Department daily. A recap sheet of these orders serves as a record to the Sales Department of orders completed, which detail is recorded to the follow-up board file, thus indicating to the counter clerk or others handling customer's inquiries, the completion date of each order.

On receipt of the order from the Accounting Department final details are recorded on the House Record, and then filed in place of the follow-up copy. Color difference in the two orders precludes any possibility of confusion. As a group of orders are shown on the board file as completed, they are transferred to a permanent bound record.

DEPOSITS

Deposit certificates are issued in duplicate. The original is given to the customer, the duplicate to the Accounting Department daily, with an adding machine tape of the money received by the Cashier. They are listed numerically, and the amount verified with the amount shown on the tape. The amount is separated into control units and posted to control accounts, which are set up according to the letters of the alphabet. Postings are made to the individual customer's deposit ledger cards, which are alphabetically arranged according to the customer's name. Considerable time is saved in posting to these cards when placed in a visible file, and also, much time is saved in balancing same to control accounts, as the balances are carried in a visible manner, which eliminates entirely the handling of the cards when taking off the balances.

Although much time is saved in the operation of a visible file over a vertical file in actual posting and balancing, the greatest amount of time saving is in referring to the file for information concerning the status of the accounts.

Of course, reference may be made to a numerical file more rapidly than to any kind of an alphabetical file that may be set up. However, the alphabetical record for control purposes has many advantages over a numerical record used for the same purpose, so that the time saving is not an issue in the use of an alphabetical file over a numerical file, but, rather, an issue in the operation of a visible over a vertical alphabetical file. The former seems to be the kind of file best suited for all purposes.

In order that the merits of alphabetically arranged deposit controls may not be overlooked, I shall outline briefly for you the advantages there over the numerical control system.

Deposits, when recorded alphabetically by customer's name, are together for each customer, regardless of the number of deposits the customer may have and regardless of the service the deposit covers. The status of all deposits for each customer is readily available. It is not necessary that deposit numbers be known before information can be obtained on any certain deposit. We have many cases of the customer having lost his deposit certificate, and with the visible record there is no time lost in tracing the service contract to obtain the deposit number. Since the deposit forms are drawn up in a manner that the deposits may be held for any and all indebtedness due us, the importance of an alphabetically arranged deposit record

may here be more fully appreciated, as all services that the customer may have are conveniently listed on the deposit card, and reference may be easily made to each of the customer's accounts, if necessary, before making refund of any given deposit. This is a definite help to the Credit Department, as it is positively known that refunds of deposit were made, under our old numerical system, when the customer was indebted to us on other accounts, or had inadequate deposits to cover other accounts.

Our deposit record is an alphabetical file of accounts as well as a deposit record, because it contains a card of every service, whether or not there is a deposit covering the service. It is more than a key to other records, because all postings concerning deposits are made to it, and the status of same is known without reference to other records. Record changes of account numbers are also worked to it.

The importance of the Customer's Accounting Section having a key to the accounts of each customer must not be overlooked. Our deposits record gives us the desired key to our water ledger cards, which are filed numerically by account number. A vertical record, used for the same purpose, would not be at all satisfactory, as too much time would be used in leafing over the cards to find the one that contained the key to the account desired. The visible deposit record, by customer's name, also eliminates much unnecessary reference to the House Record for account information, which record is by geographical arrangement, by street name and number, and meant primarily for the use of the counter clerks.

Our deposit record gives us the number of accounts of each customer, which is important information that is used for various purposes. For instance, when a customer gives us a change in mailing address we have a set-up of his services, so that the mailing address change is made to all of his services, without the customer having to specify each service.

ADDRESSOGRAPH

The service orders, when received by the Accounting Department, are first sorted into types of services. Addressograph plates are made up on all new services, and at the same time ledger and meter cards are made up. By having the ledger and meter cards set up in this manner the ledger clerk is given an opportunity of checking the work of the operator for errors and omissions. By this practice misspelled names and incorrect addresses are reduced to a minimum.

On old service orders the operator has only to make up name plates and insert them in the service plates that are already in file, our practice being that only the name plates are removed when cut-off orders are worked.

The addressograph plates are arranged in accordance with the routing in the meter books. As the accounts are given a number in meter reading order the plates are also in ledger arrangement by account number, in numerical sequence.

The plates carry the name of the payer, service address, meter number, account number, and, if necessary an address other than the service address. We have a dater plate attachment, which indicates the date of the meter reading and also a tab index arrangement. The tabs are inserted in a certain position to indicate that the service is active; when the service is discontinued the name plate is removed and the tab changed to another position, which indicates the service to be inactive.

METER READING

We are operating under what is known as the zoning system, which provides for twenty-two billing units consisting of approximately 750 customers each. Each day's reading is designed to represent a unit and such readings are controlled by a daily control account.

A work chart is made up the first of each month to indicate the unit to be read, billed, and collected each day of the month. It also furnishes a guide for the daily work of all clerks.

BILLING

Our water bills are designed to comply with the requirements of the Burroughs Public Utility Billing Machine. This machine prints the bill, posts to the ledger card and posts to the sales journal or recap sheet in one operation. The bill is printed showing the present and previous reading, amount consumed, current month charge, balance unpaid, and total due. The cashier's coupon only shows the current month charge, balance unpaid, and total due.

The operator takes a total from his machine when the billing for each control unit is completed, which is reconciled to the control ledger by the ledger clerk.

The billing for each day is completed in approximately four hours. This permits of the operator checking the bills for errors in exten-

sions, omissions, etc., before passing same to the clerk for mailing to the customer.

COLLECTIONS

As the accounts become past due daily, delinquent notices are mailed daily. These notices are made in triplicate. The second and third notices are held on the ledger clerk's desk until the fifth day following the date the first notice was mailed. They are then checked to the ledgers for payments. The notices are destroyed if the accounts are found to have been paid. If unpaid, the second notices are mailed, and the third, or Collector's notices, are given to the Credit Department for further follow-up.

CUT-OFFS, FINAL BILLS, DEPOSIT REFUNDS

It is well to have definitely defined rules to cover the manner of recording deposits and for making final bills and refunds. We have put in use a cut-off form which gives definite information for the disposition of bills and deposits.

The form was prepared in triplicate. The original is sent to the Service Department for execution, the duplicate is kept on file in the Contract Department for follow-up purposes, and the triplicate is given to the customer. By giving him an exact copy of the cut-off order he is made familiar with the conditions of it. This copy also serves as his receipt for the deposit certificate if it is surrendered, which is shown on the order. It is also used as a means of account identification when presented for refund.

When it is possible sufficient time is allowed for the order to be worked in all departments in the regular way. The date that the final bill should be completed is recorded in the column provided for that purpose. In cases where the customer must have the final bills sooner than the usual number of days to get an order through, request is made in the remarks column to have the reading phoned in. Final bills are then made up from the duplicate copy of the order.

Every effort is made to make prompt refunds of deposits, but in every case, before refunding a deposit, we make sure that the customer does not owe the company money. Reference is made to the Credit Department's unpaid delinquent file, as well as to the current file, before any deposit is authorized to be refunded. If the collection of accounts, delinquent and current, is to be properly kept up, this department is deserving of the utmost coöperation by the Contract,

Bookkeeping and Sales Departments. Final bills are not allowed to accumulate on the books for indefinite periods. In cases where it is agreeable to the customer that final bills be deducted from deposits it is done immediately. To wait until the day the customer is to call would certainly cause an unnecessary delay, as at that time if sufficient time was allowed, the final bill should already have been prepared and stamped paid; a check drawn for the remaining balance in the deposit and ready for refund.

The question of not being able to make deduction from the deposit for final bills without the certificate having been surrendered was brought up at one of our meetings. The deduction should make no difference, as it does not follow that the remaining balance in the deposit need be refunded if the certificate has not been surrendered. If need be the balance left in the deposit after the deduction for final bills may be withheld until the certificate is surrendered; however, a demand for the return of the original receipt is a very difficult rule to enforce. We have a release form being used when the customer advises that the original receipt is lost or misplaced. In cases where the customer requests us not to make deduction from the deposit it is done, regardless of his wishes, after thirty days from the date of the final bill without the surrender of the original certificate being made. This makes the surrender demand of little importance; after all it is the permanent deposit record which is particularly important and no refunds are made, even upon presentation of original deposit receipts, without reference being made to it.

Our cut-off form provides for the date the service is to be discontinued, how to gain entry to the building for cut-off and reading, if the meter is in an inaccessible place; whether or not the deposit certificate is surrendered; whether final bills are to be deducted from the deposit or paid. It is understood that the deposit in excess of final bills will be paid by check to the customer and any deficit paid by the customer promptly. In case the deposit is to be left intact, final bills must be paid within thirty days. A new mailing address is obtained, providing a means of locating the customer for the delivery of deposit refund or final bills. Whether final bills are to be held or mailed is stated, as well as the date they will be completed.

This form does much toward the elimination of confusion as it carries all the information necessary to provide for prompt handling of final bills and refunds.

The cut-off order when completed by the Service Department is

sent directly to the Accounting Department, whose duty it is to discontinue the ledger service and make up final bill. This is done in accordance with the instructions given on the cut-off order. The final bill provides a place for the deduction of deposit, with a stub for the payment of unpaid balance if any, which stub is detached in case there is no unpaid balance. If the deposit is in excess of the final bill, a refund check is made up and, with final bill, is either mailed or held in the office as directed on the cut-off order. A separate bank account is maintained for purposes of deposit refund, which is more or less of a clearing account, as no balance is maintained in it, deposits being made each day to cover the amount of the previous day's refund checks.

A record of the account, with unpaid balances, is placed on file in the Credit Department for follow-up purposes. Here, again, the necessity of a permanent mailing address is emphasized, so that an effort may be made to collect final bills, if not paid in due time.

I have confined my remarks in this paper mostly to giving details of the records used in our Customers' Accounting section. However, there are other records of equal importance. Operating records for both large and small plants should be kept. These should include an inventory of all plant equipment, a record of the amount of water furnished to the distribution system each day, amount of power used per day, pressure maintained, labor costs, plans of the distribution system, installation and removal of meters, quantities of chemicals used for treatment, and the results of the examination of all samples of water analyzed to determine their quality. This is not a complete list, by any means, and is offered only for the purpose of suggesting to waterworks men the need for proper records, and, if possible, to start a discussion on a subject which appears to deserve the attention of an association of waterworks men.

In conclusion, I shall quote an article about a man and his system, by Lois Hill.

> He waxed enthusiastic over systems. They were the breath of life to him. His ingenious brain was forever producing wonderful new methods whereby efficiency might be increased. He talked system. He exuded efficiency from every pore. His desk was always clear of papers. They were all carefully filed in endless numbered folders ranged in geometrically accurate rows along a table. He adorned the walls above his desk with lists of things he intended doing, had done, and was doing. The idea being that you crossed each item off as soon as accomplished, and having erased one item, you made out a fresh list so that you were always up-to-date and neat. His pencils and pens lay

in parallel lines with his ruler and scissors. His paste-pot occupied a position to leeward of the inkstand, and that position was permanent. It was all part of his perfect system to have everything just so. He drew up wonderful schemes and kept countless neatly-ruled note-books, memorandums and schedules and lists, schemes and wire-baskets and card-indexes; every device for keeping the office tidy and the desk clear; every possible method of recording business activities, he discovered and invented and utilized.—But, do you know, despite all this specialization and system, he could never get the work out on time? It took him all his time to keep his system in order;—you see there were memos to be kept up-to-date; lists and schedules to be constantly revised; indexes and folders and files to be checked; it was all a tremendous responsibility, and naturally the work piled up and waited, and waited,—and went on waiting.

And the moral of all this is that it is possible to over-systematize business. It is no use trying to make the office look like a drawing-room; keep it as pleasant and cheery as you can, but do not forget that fundamentally it is a *work-room;* it is meant to be used.

System is all a matter of common sense, a matter of putting things where you will be able to find them—and quickly. It does not require a complicated paraphernalia of note-books and memos to keep a clear record of work.

Work systematically, but do not over-burden yourself with system. A surfeit of anything is as bad as an insufficiency.

CLEANING OF WATER MAINS[1]

By William H. Grotz[2]

Water-main cleaning is not a new problem. It has been in the past a subject of much discussion and will probably be so in the future. The question of how to obtain the most out of the water main is one which should engage the interest and attention of all water works engineers, inasmuch as the expense of greater pumping pressures depends in great measure upon the carrying capacity of the mains.

Our first experience in water-main cleaning in Buffalo was in the year 1920. During the winters of 1918 and 1919, the water pressure in certain sections of Buffalo, especially in the low service system, was found to be extremely low, particularly during the periods of heavy consumption of water. This condition was especially noticeable in those areas in which the large industrial plants and railroad yards were located.

In view of the excessive cost of laying a new feeder to this district and the fact that the mains supplying these areas were of ample size to deliver the water consumed without excessive loss in pressure, it was determined to make an investigation into the cause or causes of this condition.

Accordingly, during the summer of 1919, an inspection was made of the interior of all mains cut for repairs, new connections or alterations, to determine their condition.

BUFFALO'S DISTRIBUTION SYSTEM

At this time it might be well to state that the water distribution system of Buffalo is divided into two services, a high-pressure service having an average pressure of 50 pounds, and a low-pressure service having an average pressure of 30 pounds.

This inspection showed that mains which had been in the ground twenty-five years and longer were badly silted, having a deposit of mud from 1 to 4 inches in depth. The presence of these deposits had

[1] Presented before the Canadian Section meeting, March 8, 1928.

[2] Assistant Engineer, Bureau of Water, Buffalo, N. Y.

greatly reduced the carrying capacity of the mains, with consequent reduction in pressure.

Believing that it was possible to increase the carrying capacity of these mains by cleaning, a contract was entered into with the National Water Main Cleaning Co., in August, 1920, to clean approximately six miles of mains, mostly on low service pressure, with a view to increasing the carrying capacity and pressure.

The first main to be cleaned under this contract was a 16-inch feeder, in the low service district. It was approximately 4,200 feet long and included a number of 45 degree bends to dip under a tunnel and pass other obstructions. It had been laid about thirty-five years previously. The result of the cleaning of this main showed conclusively the necessity and wisdom of continuing the investigations.

THICK MUD FROM MAINS

Shortly after the cleaning machine had started on its journey through the main, the open end began to disgorge a thick, pasty, writhing mass of mud completely filling the open end. The emission of this mud reminded one of shaving cream being squeezed from a tube, the difference being in the color and odor. In all, fifteen dumploads of dirt were hauled away. When this main was restored to service a marked improvement was noted both in pressure and volume, in the district supplied.

Continuing under this contract, several other low service and several high service mains, comprising over 35,500 feet of 16-inch pipe, were cleaned, with uniformly satisfactory results.

In two mains cleaned in the low service, silt to a depth of 10 inches was encountered, with the result that the capacity of the pipe was decreased two-thirds. The mains on the high service had been laid forty years before, and while the silt in these was not excessive, the carrying capacity had been decreased at least one-half by tubercular growth and incrustation on the inner side of the pipe.

As a result of the cleaning of these mains, it was determined that low service mains laid twenty-five years or longer, were badly silted and that their carrying capacity could be increased at least 100 per cent by cleaning, while mains on the high service, laid twenty years or longer, were badly incrusted and their carrying capacity could be increased considerably.

The work done under the first contract having given excellent

results, a further contract was entered into in 1920, providing for the cleaning of an additional 190,000 feet of 10- to 20-inch mains, in the low service district. The results of cleaning these mains were extremely satisfactory, the pressure at the recording gauges in various parts of the section registering an increase of from 7 to 10 pounds, which was from 25 to 30 per cent greater than before the work was done. Also sections which had been complaining of lack of water were now receiving an ample supply.

It was then deemed advisable and in the best interests of the city to continue the cleaning of all mains in the distribution system which had been laid twenty-five years or longer. The cleaning of these mains would not only materially increase the amount of water available, but decidedly reduce the friction losses in the pipe, so that a lower pressure might be maintained at the pumping stations. This was especially desirable as practically two-thirds of the pipe in the system was of Class "A" weight and suitable for a pressure much less than that which they were carrying.

It was also highly desirable to have clean mains for clean water when the filtration plant, which was then contemplated, was completed. This plant is now in operation.

METHOD OF OPERATING MACHINE

Cleaning a water main consists of inserting the cleaning machine or scraper into the pipe, and then forcing or pulling it through the main, cutting tubercules and other matter from the surface, and scraping out the mud, as it moves along. In cleaning the smaller mains up to and including 8 inches in size, the machine is dragged through by a cable. First a small line is carried through the pipe by a ball float. A cable is then drawn through the main by this line, and finally the scraper is pulled through by this cable, using a windlass. In mains 10 inches and larger in size, the cleaning machine is forced through by the water pressure behind it.

The procedure in cleaning a water main is simple. A section of pipe to be cleaned is valved off from the system. A cut is made in the pipe at each end for entering and removing the cleaning machine. The machine is then inserted at one end and the pipe replaced and sleeved up. At the other end a riser pipe of the same size as the main is made up with a 45 degree bend and extended to the surface. Water is then turned on back and the cleansing machine and the

cleaning begins. The machine travels quite rapidly, making 200 to 300 feet per minute, and, coming out at the open end of the main, brings all the mud, encrusted material and other loose materials in the pipes with it. The water is allowed to run for a short time after the machine is out to flush out loose particles. The pipe is then made up and all valves opened.

The time any section of pipe need be out of service, depends upon the speed with which the pipes can be cut and sleeved up, as the time required for the machine to travel from one end to the other is very little. Usually it can be arranged so that larger mains need be out of service less than twelve hours, and smaller mains from four hours up.

In Buffalo, the work of cutting and sleeving mains, as well as the excavation, back filling and other work, was done by the contractor, the water department furnishing only two men to operate the valves and a foreman to direct and check up the work. The water department furnished pipe, specials, lead and yarn, while the contractor furnished all other materials and equipment.

The cleaning device usually consists of two sections flexibly connected, each having a number of tempered steel cutting and scraping blades securely fastened to a common centre, the cutting blades being on the forward section. The centers are of pontoon type, providing the proper buoyancy, so that scrapers and cutters exert equal pressure on all sides of the pipe. The cutting edges of these blades form a circle somewhat larger than the diameter of the pipe to be cleaned, so that when entered into the pipe there is enough tension on the blades to cut away all incrustation. The cutting edges of the scraping blades are turned at an angle of forty-five degrees to the line of pipe, so as to give a wiping contact. A leather disc mounted in an expanding steel cage is provided to propel the device through the pipes, and provision is made to allow enough water to pass the machine to carry ahead of it the silt, incrustation and other matter in the main.

The cleansing of mains laid twenty-five years or more was continued through 1920 to 1924, and included about one-fourth of the pipe in the distribution system. Some of the larger feeder mains still remain to be cleaned.

COST OF CLEANING MAINS

The sizes, amounts of pipe cleaned and costs are given in table 1.

An idea of the cost of the coöperative work done by the water department in connection with pipe cleaning may be gained from the

fact that the department cost on the 6-inch pipe cleaned in 1924, was between five and six cents per foot.

It is surprising to see the amount and variety of loose objects that come out of the pipes when cleaned, especially in view of the general precautions used when laying mains to insure that the pipes are clean. These include paving stones, cast-iron tapping cuts (old style), oak sticks and wedges, iron bars, timber and what not. From a 10-inch main, an 8 by 8 inch by 5 foot piece of maple was removed. A 36-inch main disgorged a 6-foot trench ladder, a 3 by 2 by 1 foot box, a small door, a tool box, tools, miscellaneous pieces of hemp, wood, etc. Large pieces of lead from joints which had missed were

TABLE 1

Amount and cost of water-main cleaning in Buffalo, N. Y.

YEAR	6 INCHES	8 INCHES	10 INCHES	12 INCHES	16 INCHES	20 INCHES	24 INCHES	36 INCHES	TOTALS	COST
	feet		*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	
1920					35,545				35,545	$3,909.95
1920			70,639	78,244	54,216	17,020		5,425	225,544	67,663.20
1921	25,989		65,701	38,338	33,625	42,664	8,259		214,576	64,372.80
1921*					18,508				18,508	5,552.40
1922			9,251	34,245	57,422				100,918	27,247.86
1923	41,280		17,070	32,968	44,085	6,795	4,947	2,863	150,008	40,502.16
	130,137								130,137	35,107.02
Tot.	197,406		162,661	183,795	243,401	66,479	13,206	8,288	875,236	$244,355.39

* Extra.

common, often weighing as much as 50 and 100 pounds. One 36-inch main was so heavily laden with silt, that when cleaned, this silt accumulated to such a depth in a low spot on an adjacent street over which a street railway was operated, as to necessitate the use of a snow plow working several hours to keep the mud off the tracks, until it could be removed and the tracks kept open for traffic.

BENEFITS TO THE COMMUNITY

In conclusion it might be well to consider the benefits and savings to the community by having the water mains kept in a properly clean condition. These are manifold, but a few of the important ones are:

a. Reduction of pressure at pumping station, resulting in a coal saving commensurate with the size and age of the system.

b. Pressure and volume increase throughout the entire system, and particularly in the remote sections, thereby decreasing fire hazards and lessening the chances of complaint from the consumers.

c. Delay of extensive new larger main extensions.

d. Potability and clarity of water.

Upon recent examinations of several mains which have been cleaned in Buffalo, they were found free from tuberculation, thus proving the wisdom of cleaning. It would be well for those interested in a pure potable water and a properly balanced system, to examine water mains from time to time for tuberculation and silting.

DISCUSSION

MR. MILLER: It strikes me that, in putting this cleaning machine through a larger pipe by water pressure, some one of these timbers or iron obstructions they find in the pipes, might be struck, and it would be difficult to know where the machine might be at any time. Is there any way that measurements could be taken in order to ascertain where the trouble occurred?

MR. GROTZ: We had a number of occasions where that happened. It is quite a simple operation to follow that device through the streets, by means of the valves or hydrants. We put a man at every other valve, and he listens in. He has a little telephone, and he can hear the machine until it passes the valve, then he passes along to the next valve, and if the machine does not come through he can listen in on the pavement, and he can hear sufficient noise to know where the machine is. Then we know where to cut the pipe and pull it out.

MR. GORE: The cleaning of water mains is always an interesting proposition for anyone to undertake. As Mr. Grotz has stated, you will find a series of different things coming out of the pipes. I know of one case where a wheelbarrow was taken out, and we frequently have workmen's dinner pails and a large number of rocks, and things like that.

In unfiltered water the main becomes clogged more frequently. Tuberculation is entirely an electrical matter. It is formed where the electrical current passes from the pipe into the water, and it is a perfectly natural process. The water passing down the main acts as a carrier for the electricity. The electricity comes out of the pipe at the nodule and goes in at some other point.

Experiments were carried on in connection with the Coolgardie main under my direction some years ago, and we found it very hard to determine the exact cause of the corrosion experienced.

In one main, 42 inches in diameter and 13 miles long, it was found that the obstruction was largely manganese dioxide. It was thought that this could be eliminated by putting in a scraper of the type that Mr. Grotz has referred to, and a kind of horizontal block was devised in which brushes were used in two parts. One part formed blades which caused the water to spin in one direction, which, impinging on the other part, caused it to rotate as a turbine brush.

These brushes were sent down the main, and we ran up against the problem of where these turbine brushes were, because they made no noise whatever. In order to get some indication of where they were, we put on a screw propeller that lifted a trip hammer, so that at intervals there was a bang that could be heard. It did not move as fast as indicated by Mr. Grotz, but we could always find it.

After the brush had gone through, I went down into the main and found it quite clean, although there were fine tuberculations which had to be removed. It has been found since that the effect of cleaning where these tuberculation had taken place was that it formed much more rapidly after the cleaning than it did in the first instance, and this particular main had to be cleaned every few years.

I know of another main, 48 inches in diameter, that was put in seventy years ago. Tuberculation started and covered the pipe, and those in charge considered whether they should scrape it out. They came to the conclusion in that particular case that they would prefer to leave the main exactly as it was, because it had got down to the condition where its discharge ceased to reduce further.

That is a matter that has to be considered—whether it would be better to clean the main or let it go on. Of course, if there is a deposit like manganese dioxide, then there is no doubt about the value of cleaning operations.

Mr. Burt Hodgman: We have had considerable experience in cleaning large mains. We have used the turbine where there have been limestone deposits in the pipes, but we do not use it to eliminate iron scale, because the turbine actually does cut it out. We have learned to temper the blades to such a point that they will not scrape the coating away. We have found that the scale does come back very rapidly. I might mention Charleston, South Carolina, where the main went back very rapidly.

We had a very peculiar case at St. Louis, where they had used lime a great deal in the water, and the lime had apparently eaten away the coating on the small mains. In a 6-inch main we found that, where the carrying capacity was 38 per cent before cleaning, it got back after cleaning to 95 and 100 per cent, and in four or five months after cleaning, it went back to 80 per cent, and in four years it got back to 65 per cent.

But the large mains at St. Louis that were cleaned at the same time as the small mains fifteen years ago, dropped back less rapidly, and the large mains that we cleaned there are standing up now just as well as new pipe.

Where the mains carry very soft water, the scale will start very rapidly after the pipe is cleaned, but as soon as the first covering of scale is on the pipe, re-scaling slows up, and does not increase any more rapidly than in a new pipe. We have had hundreds of examples of that. I think that one of the best proofs is that several of the privately owned companies which have had experience in cleaning pipes for years, are continuing the cleaning, because they consider it much cheaper than laying new pipe.

A MEMBER: Have you had experience in cleaning large steel mains?

MR. HODGMAN: We have not cleaned any steel mains larger than 12 inches in diameter. But in cleaning a large steel main there is an additional trouble, and that is that it is not always round. We have developed a machine in which the blades are carried on spring arms to allow for changes in the shape of the pipe. I do not think that there is any more danger of corrosion in steel than in cast iron.

Our turbine machines do cut off the corporation cocks; they grind them right off, flush with the pipe. Our regular scraping machines have the blades so tempered that they will spring over the end of the corporation cock, but they will not spring over the ledge.

We cleaned 150 miles of pipe in Brooklyn in which there were a number of driven funnels over 150 feet, that extended into the pipe an inch and a quarter, and we did not loosen one of these funnels.

MR. SANDERSON: I do not quite understand how the paint can be left on the pipe and still the tubercular growths be removed, and I would also like to ask why the large mains at St. Louis showed a lesser reduction in carrying capacity than the small ones.

MR. HODGMAN: We have never been able to explain that. The only thought was that perhaps due to a higher velocity in the small mains, and more of that lime-treated water passing at the surface, it affected the coating before the scale started.

In regard to your first question, it is entirely a matter of temper and shape of the blade. The blades conform to the diameter of the pipe, and they run so hard that they will scrape heavily. We prefer to use soft sets rather than one set of blades that will scrape everything at once. It sometimes takes several sets of blades to scrape the scale off. One set of blades which would do the work would have to be so hard that they would scrape right through. We had a very good example of that where there was lime scale on a pipe. We have taken out sections showing the cutting, and the pipe was smoother than it was when originally laid, because the blades left the lime scale in the holes and did not cut it all out.

MR. GORE: I have examined the coatings at the site of tubercles in some of these pipes with an ordinary small pocket magnifying glass, and you cannot even distinguish the pin holes; undoubtedly there must be a hole or the iron would not pass through it. The coating looks exactly like it was when it was put on, but you can find the spot where the centre of that nodule was, and if you examine it very closely you will find a pedal curve to the nodule itself, of soft, corroded iron, deepest at the center of the nodule.

If you take a clean piece of bright iron and connect it to a piece of lead, and then put it into clear water, and watch, what goes on, you will see the iron being shot into the water in the form of projectiles, showing that the iron is shot out with high velocity and it then combines with the oxygen in the water.

There are all sorts of compounds of iron. I believe that iron has more compounds of oxygen than any other substance. It is said that iron has more vibrations than a grand piano. This oxygen forms in the water and you can see it change in the water; first it is slightly yellow, and then it gets the nice reddish color with which we are familiar.

ELECTRIC MOTORS[1]

By E. A. Reid[2]

This paper will describe briefly the various kinds of motors which might be of interest to the water supply industry. The differences in their construction and operating characteristics and the ways in which these characteristics adapt a type of motor to a particular application will be discussed.

Motors, in the first place, may be divided into direct and alternating current machines. With minor exceptions of no great interest to this group, they are not interchangeable. That is, in general, an alternating current motor will not operate on direct current and vice-versa. Although direct current motors have certain features which give them decided advantages for many uses, they are not used in general, due to the difficulty of transmitting direct current for any appreciable distance. When the characteristics of the load are such as to make the use of direct current motors almost imperative, the power is transmitted by alternating current and transferred to direct current by a rotary converter, motor generator set, or other means, at or near the point of application. The load characteristic which requires direct current motors is usually frequent starting under heavy loads such as we have with elevators or street cars. Since this type of load is not present in this utility to any extent, the paper will be limited to alternating current motors.

Alternating current motors may be divided into two general classes; induction and synchronous. The first of these, the induction motor, is far more generally used than all other types combined. The induction motors may further be divided into two general types, the squirrel cage and the wound roter type. The first of these gets its name from the construction of its rotating member, or rotor, which consists usually of copper bars imbedded lengthwise of the motor shaft in the iron core, and connected together at the ends by copper rings. This simple design of copper bars, visualized as existing without its supporting iron core resembles closely the rotating wheel of the familiar squirrel cage.

[1] Presented before the Illinois Section meeting, March 30, 1928.

[2] Professor of Electrical Engineering, University of Illinois, Urbana, Ill.

The wound rotor type has a winding of many turns to replace the imbedded copper short circuited bars of the first described type. This wound rotor may be short circuited on itself as are the bars of the squirrel cage type, or may be connected to a resistance inside of the winding or to an external resistance through slip rings and brushes. In either case the resistance will be so arranged that it may be varied, either manually or automatically.

It can easily be seen that the squirrel cage type is much the simpler and cheaper type. Practically the only troubles that it can give are due to mechanical wear in the bearings which might let the rotor drag on the stator, or burning out of stator winding due to improper fusing. Since there are no moving contacts there is no danger from arcing and no contacts to keep clean and replace when worn. The great disadvantage of this type is that it does *not* develop much power at start and *does* draw a large current from the line during the starting

TABLE 1

Characteristics of squirrel cage motors

PER CENT RATED VOLTAGE	PER CENT RATED CURRENT	PER CENT FULL LOAD TORQUE
40	112	32
60	250	72
80	450	128
100	700	200

period. As a result of the large current drawn from the line, power companies usually require that any motor above 5 to 10 H.P. be started through a compensator. This compensator or auto transformer, serves to reduce the voltage and to prevent excessive current demand at starting. Although this limits the current it also cuts down the starting power.

Table 1 shows the relation between impressed voltage, starting current and starting torque for typical squirrel cage motors.

Since a motor to be started under full load requires more than full load starting torque, it is seen that full voltage probably would have to be applied, with consequently large current—700 per cent—in order to start the load. This large current would draw down the voltage and the torque would be further reduced. In other words, if the static load is very great, this type of motor very likely will not start the load at all. Even to start under no load other than the

friction of the pump or other machine, requires such a large current and consequent line disturbance that many electric companies limit the size of this type of motor that they will allow to be connected on their lines. I believe one company operating in this state limits the size to 50 H.P. Hence the squirrel cage induction motor is limited to comparatively small motors where the load does not come on until full speed is reached.

The starting torque depends upon the resistance of the rotor, being greatest for a fairly high value. On the other hand, the value of rotor resistance which gives best starting torque will give very poor running characteristics. Hence it is seen that it would be desirable to have some means of varying the rotor resistance—increasing it for starting and decreasing it as the motor comes up to full speed. The wound type of motor gives us this opportunity. A resistance may be mounted inside the rotor and a centrifugal device attached which will throw out at a certain speed and cut out the resistance, or a handle may be brought out through the shaft in such a way that the operator may cut out the resistance while the motor is running. The more common way, however, is to bring out the ends of the windings to slip rings on the shaft and connect an external resistance through brushes. This external resistance may be varied manually as the motor comes up to speed or automatically through relays. A motor of this type is installed on one of the wells of the local plant and starts automatically through a resistance which is cut out in steps as the motor comes up to speed. The slip-ring motor in this case is not used to obtain large starting torque, but to prevent overheating or shut down of the motor in case of frequent failure of voltage. This is particularly desirable when the voltage failures are momentary, as the motor has time to slow down and then, with the return of voltage, would, without the resistance, draw a large current with consequent opening of cutout, or motor heating. This type of motor and control of course introduces more complications and sources of trouble in burning of contacts, etc., but I believe the local installation as a whole has been quite satisfactory. As in this case, this automatic feature is especially desirable where the motor is located at a distance from any attendant, since the motor will automatically come back into service after any voltage failure, without replacement of fuses or other cut-outs.

Table 2 shows relative values of starting torque and current for wound rotor type induction motors.

Comparing this with the squirrel cage type we see that we get the same starting torque with about one-third the starting current. Due to the fact that a coil winding cannot be made as low in resistance as a squirrel cage, the wound type of motor will be slightly less efficient. It will also be more expensive.

Another application for which the wound type with variable external resistance can be used when the squirrel cage cannot (without special features) is where it is desired to vary the speed. Any desired speed can be obtained by inserting various amounts of resistance in the rotor circuit. Any speed below the maximum, however, means a reduced efficiency and reduced power output. Hence continuous operation with resistance is wasteful. The recent development of various efficient gears and gear shifting devices offers an alternative method of speed variation. In this way maximum motor output and efficiency may be secured at all speeds.

TABLE 2

Characteristics of wound rotor type motors

PER CENT RATED CURRENT	PER CENT FULL LOAD TORQUE
150	100
250	200

Certain companies have brought out a motor which attempts to combine the advantages of both of the above types. If the bars of the squirrel cage type are made thin and deep, it is found that they have greater resistance at standstill than when running. This then automatically changes the rotor resistance from a high value at starting to a lower value when running, and hence combines to a certain degree the simplicity and absence of moving contacts of the squirrel cage type with the variable resistance feature of the wound type. It does not increase the starting torque to the extent that can be obtained by the wound rotor type, but does limit the starting current and can be thrown directly on the line without the use of a compensator. It undoubtedly has a field of usefulness where it is desired to limit the starting current and where maximum starting torque is not necessary. Advantages are: the saving of the cost of the compensator, and the reduction of the starting operation to simplicity itself.

One of the disadvantages of all types of induction motors is that

they do not operate at unity power factor. Power companies are realizing more and more the cost to them of low power factor loads, both in increased investment and increased lines losses, made necessary by low power factor; and not paid for by the consumer on a kilowatt hour rate. As a result, every year sees more contracts and rate schedules containing so called power factor clauses which penalize the user for low power factor. If induction motors are kept fully loaded, their power factor will run from 85 to 92 per cent. If, however, the load varies, the power factor may drop as low as 30 per cent. It is not always possible to keep all motors on a system fully loaded. In motors driving deep well pumps for example, if pumps are not kept in the best of condition, the load and power factor drop off. Hence, an average power factor of 70 per cent or lower would not be uncommon. This means that the electric company has to have about 40 per cent more current capacity than with unity power factor and that this extra capacity is not being charged for unless the rate has a power factor clause. With such a rate it may pay the user to correct his power factor. This may be done in several ways. A synchronous or rotary conden er may be used; or in sizes of 100 H.P. or above, synchronous motors may be used in place of induction motors. This motor differs from the induction motor in that its power factor may be controlled. The induction motor draws a lagging current. The synchronous motor may be made to draw a current at unity power factor or even to draw a leading current and thus cancel some of the lagging current drawn by induction motors on the same system. This would seem then to be an excellent type of motor. Unfortunately it has serious disadvantages, one of which is that it must have for its field excitation a direct current source. Its starting characteristics are no better than the cage type induction motor, and it cannot be economically built in small sizes, that is, 100 H.P. or less. Hence in a system requiring a number of small motors its use would be limited to that of a rotary condenser. In other words one synchronous motor could be operated without load to compensate for the low power factor of a number of induction motors.

It might also be of interest to know that fairly recently a so called synchronous induction motor has been placed on the market. This motor combines the good starting characteristics of the wound rotor induction motor with the good power factor characteristics of the synchronous motor. As a matter of fact it *is* an induction motor with high starting torque on starting and automatically becomes a syn-

chronous motor when full speed is reached. This type of motor is worth considering in an installation of small motors where good power factor is of importance. It does not require a source of direct current as it has its own exciter built in. Its disadvantages are: greater cost than induction motors; more complicated; and slightly less efficient. The individual case would have to determine whether these disadvantages outweighed the advantage of good power factor.

Time is too limited to discuss the power factor situation in detail. Whether or not it would pay a consumer to correct would depend upon the penalty he was paying and the cost of corrective devices. There are a great many companies using a power factor clause and there are almost as many different methods of applying the penalty. hence the best action to take would have to be worked out for the particular load condition and rate. One company in this state makes a very simple application as follows:

Five per cent discount from net bill if power factor is maintained at 80 per cent or better, 10 per cent if 90 per cent or better. Under this rate a company with a bill of $2000 monthly and an average power factor below 80 per cent would save $200 a month by bringing the power factor up to 90 per cent. As stated before, whether the added investment and operating costs of the corrective equipment would be such as to make it pay would have to be worked out for the particular load.

FILTER OPERATION AT VARIABLE RATES[1]

By Harry N. Jenks[2]

Although it is customary to rate the capacity of a rapid sand filter at 125 m.g.d., throughout a rather broad range of quality of applied water as respects bacterial load and pre-treatment efficiency, yet under certain favorable conditions it appears quite proper to design filters on the basis of a higher rate of filtration. A notable case in point is the new filtration plant at Detroit, Mich., where the allowable rates of filtration were considered as being approximately 160 m.g.d., because of favorable quality of the lake water. Nevertheless, it was reported at the Buffalo convention of this Association[3] that deterioration of the filter effluent took place at rates above 135 m.g.d. This statement gave rise, at the meeting, to the question, "What is the capacity of a rapid sand filter?"

Taking the assumed standard rate of 125 m.g.d. as the basis of comparison, the actual capacity of a filter to deliver a satisfactory quality of effluent at higher rates depends primarily upon the physical conditions under which the filter operates, and upon the nature of the overloading as related to the extent and duration of such overloads. As filters are seldom operated at overloads on a constant rate of filtration basis, the question of filter capacity arises when such plants are operated at variable rates.

It is contended by some designers that filters should not be operated at other than a constant rate of filtration. Based on his experience in the operation of a 32 m.g.d. filtration plant at Sacramento, Calif., the writer is inclined to doubt the general applicability of the theory that filters should necessarily be operated at a uniform rate. At the plant mentioned, the rate of filtration is continually varying to meet the fluctuating demands of the distribution system, and, if overloading is kept within certain ascertained limits, the quality of the effluent is entirely satisfactory.

[1] Presented before the Iowa Section meeting, September 28, 1927.

[2] Sanitary Engineer; Associate Professor of Sanitary Engineering, Iowa State College, Ames, Iowa.

[3] William M. Wallace: "Eighteen Months' Operation of the Detroit Filtration Plant." Jour. Am. W. W. Assn., Vol. 16, No. 4.

Just what these limitations are, or possibly may be, in other plants, was studied by the writer from comprehensive data gained through

TABLE 1

Study of filter overloading during critical period

PERIOD	OVERLOAD HOURS		WEIGHTED AVERAGE OVERLOAD (*Ov*)	AVERAGE LENGTH OF FILTER RUNS (*F*)	OVERLOAD CONSTANT (*K*)
	Total during period	Per day (*T*)			
			per cent	*hours*	
June 1– 7	63	9.0	21.0	9.3	10,100
June 8–14	48	6.9	14.8	11.0	8,800
June 15–21	62	8.9	19.0	11.8	12,500
June 22–28	71	10.1	18.2	12.5	14,900
July 29– 5	81	11.6	22.0	8.1	11,500
July 6–12	86	12.3	27.1	8.4	13,100
July 13–19	101	14.4	35.4	5.7	11,100
July 20–26	112	16.0	34.5	4.7	10,100
August 27– 2	119	17.0	30.6	6.5	14,400
August 3– 9	72	10.3	23.1	7.9	10,000
August 10–16	77	11.0	17.4	10.0	12,900
August 17–23	25	3.6	17.2	8.4	(3,550)
August 24–30	58	8.3	17.5	7.8	7,600
Median value of K					11,300

The overload constant

$$K = T \times L \times F$$

where T = total overload hours per day, L = total filter loading in per cent ($= 100 + Ov$), F = average length of filter runs, hours.

Hence for any assumed conditions of filter overloading, the resultant length of filter runs may be approximately predicted from the equation

$$F = \frac{K}{L\,T} = \frac{11{,}300}{L\,T}$$

The degree of overloading is therefore limited, on the basis of minimum permissible length of filter runs, according to the foregoing equation. For limitation of filter overloading according to the criterion of quality of effluent, see table 2 and figure 1.

a season of continual filter overloading at the Sacramento plant. A brief statement of the conclusions based on this study may be of interest to those at this meeting. A consideration of this subject

should also prove of value to any who have occasion to study the possibilities of variable rates of filtration in connection with the design of medium-sized filtration plants. This is particularly true where there is limited filtered water storage, with the consequent need for speeding up the rate of filtration to meet peak demands.

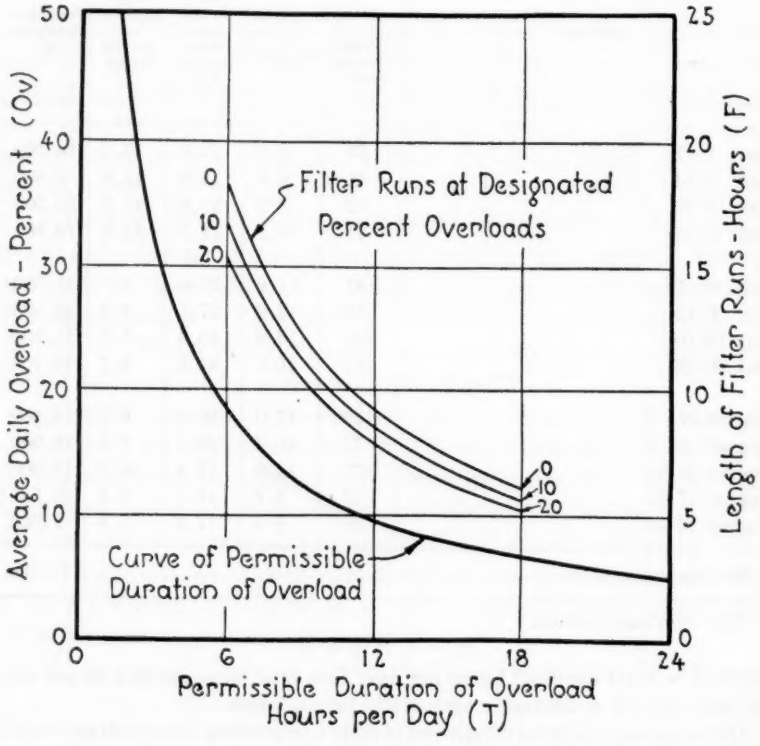

FIG. 1. RELATIONSHIP BETWEEN AMOUNT AND DURATION OF OVERLOADING COMPATIBLE WITH SATISFACTORY QUALITY OF FILTER EFFLUENT

(Based on a Study of Filter Overloading during Critical Period of Maximum Water Consumption.)

As such a situation may frequently arise in Iowa towns, there appears good reason to believe that the designer may avail himself of the ability of a filter to withstand reasonable overloads, in order better to enable him to design elevated tanks or balancing reservoirs of smaller size than might otherwise be possible.

CRITERIA OF PERMISSIBLE FILTER OVERLOADING

Length of filter runs

Overloading causes premature clogging of a filter, with consequent shortened filter runs and excessive use of wash water. This condition, during times of heavy demand, has the further disadvantage of curtailing the possible hours of operation of the filter. This of itself tends to induce even higher rates of filtration, and thus to establish a vicious circle, to the serious impairment of filter operation. Shortened filter runs of themselves do not necessarily result in an

TABLE 2

Schedule of overloading compatible with satisfactory quality of filter effluent

AVERAGE PER CENT OVERLOAD (Ov)	PERMISSIBLE QUANTITY OF WATER FITERED AT AN OVERLOAD (Q)	EQUIVALENT PERMISSIBLE HOURS OF OVERLOAD (T)
5	4.20	24.0
10	2.10	11.4
20	1.05	5.2
30	0.70	3.2
40	0.525	2.2
50	0.42	1.68

The proposed schedule is based on the assumption that the maximum continuous overload should not exceed 5 per cent, equivalent to a rate of filtration of 131 m.g.d. It is further assumed that the amount of water filtered above normal should be in proportion (indirect) to the overload.

The computed permissible hours of overload are believed to represent the safe duration of the corresponding overloads. The values expressed by the table are equivalent to approximately 50 per cent of the effective overloading that caused serious impairment in filter operation during the critical period studied in table 1.

unsatisfactory product from the filter, but they do indirectly contribute to the weakening of that main line of defense against bacterial contamination of the filtered water.

In this connection, the results of a detailed study of filter overloading at Sacramento is presented in table 1. As the values in the table embrace every hour of overload from June 1 to August 30 of the year under consideration, it may properly be assumed that the median value of the overload constant (derived as explained in the footnote to the table) is characteristic of this particular plant.

The equation deduced from the data of table 1, giving the length

of filter runs in terms of the total filter loading above normal and the duration of that loading, shows empirically that the filter runs vary inversely as the product of the last-named factors. This relationship, it may be presumed, should be of general application. In the case of filters in better physical condition than obtained at the time for those studied, or with an applied water possessing more favorable characteristics with respect to filtration, the value of the derived constant, K, would doubtless be considerably increased.

The filter run equation is shown in figure 1 for designated overloads of 0 to 20 per cent. A valuable conclusion that may be drawn from an inspection of these curves is that the length of filter run decreases much more rapidly with increases in *duration* of overload than with increases in the overload itself. This fact furnishes corroboration of the assumption that filters, designed to operate at variable rates, may be run at considerable overloads, provided the peak rates are of comparatively short duration.

Criterion of quality of filter effluent

Following the line of investigation of filter overloading still further, the mass of laboratory data for the period under review show a marked decrease in filter efficiency as a result of overloading beyond fairly well-defined limits. A careful analysis of the extent of overloading, interpreted in the light of observed serious impairment of filter operation with regard to quality of filter effluent, led to the conclusions embodied in the schedule of overloading compatible with satisfactory quality of filtered water, presented in table 2. As stated in the notes, the proposed permissible hours of overload are equivalent to approximately 50 per cent of the effective overloading that took place at the time the study was made. These values, although admittedly somewhat arbitrary, are suggestive of what may be considered safe practical limits for plants treating reasonably high bacterial loads and in good physical condition, particularly in respect to the sand in the filters.

CONCLUSIONS

1. Provided that overload rates are kept within proper limits, the operation of filters at variable rates of itself has no deleterious effect on the quality of the effluent, as compared with operation at a constant rate.

2. By varying the rate of filtration to correspond to the curve of

water consumption, it may be possible, under favorable conditions, to reduce the size of storage reservoirs or elevated tanks, to an extent otherwise inadvisable.

3. Apparently, the length of filter runs that may be expected when filters are operated at overload rates, is equal to some constant divided by the product of the total loading (expressed as a given per cent of normal) and the duration of such loading. It is suggested that it would be of value to determine this constant for various types of water as treated in different plants throughout the country.

4. Filter runs are shortened to a much greater extent by the duration of overload rates of filtration than by the amount of such overloads.

5. As judged by the criterion of quality of filter effluent, the permissible duration of overloads decreases rapidly with increases in rates of filtration above normal.

WHY METERING PUMPAGE PAYS[1]

By Charles W. Parsons[2]

Water works superintendents and consulting engineers, designing improvements for water works plants, are confronted with an almost infinite variety of important problems. The recent rapid strides in reducing operating costs by increasing plant efficiency, have demanded that accurate knowledge of all existing conditions be available in convenient form. The installation of meters and instruments has brought the superintendent and the engineer squarely up against the problem: "Does metering pumpage pay?".

Two cities, for example, have found this metering problem confronting them. Similar conditions apply in so many other cities that their particular problems seem worth outlining briefly.

The smaller city derives its supply from wells. The two deep wells are pumped by two-stroke, deep-well plunger pumps, and the shallow well, located in good water bearing sand and gravel strata, is pumped by a multi-stage deep-well turbine. The wells are located in different sections of the city and the well pumps discharge directly into the distribution system. An elevated tank serves as an equalizer.

The plunger pumps in the deep wells had not been equipped with meters at the time they were installed, and other use for the limited funds of the water department seemed to excuse the installation of these meters. Whenever there seemed to be a prolonged use of larger amounts of water, the thought would arise that leaks in the mains had developed and a careful search would be made to locate them. Eventually decision would be reached to shut down the pump for a week and proceed with the slow work of pulling the pump rods. Often the efforts and expense were rewarded by finding the pump leathers badly cut. These leathers would be renewed and the pump put back in service. On several occasions, however, this expense and shut-down were in vain, as the pump leathers were found

[1] Presented before the Illinois Section meeting, March 30, 1928.

[2] Republic Flow Meters Company, Chicago, Ill.

in first class condition. Later on a larger leak showed up, which had previously found its way into the sewers while the pump was being accused of developing a large slip.

The healthy growth of this city required the installation of a third well, and the gravel stratum was discovered and a turbine pump was chosen. The city decided they should have some definite means of knowing what the well was producing, as they could not count the strokes of a turbine pump and they hesitated at the thought of the cost and delay of pulling the turbine for unnecessary inspection. A master meter of proven type and manufacture was installed with the pump. It served as a means of testing the well and checking up on the guaranteed delivery of the pump. A continued check was thus provided on the well yield, pump capacity, total pumpage, and exact time when the automatic control started and stopped the pump.

The city soon asked themselves why meters should not be placed on the other well pumps. They argued that such meters would not only give them the exact total pumpage to be checked against the house meters, but the meter charts would show immediately any reduced pump discharge and would indicate if this reduction in gallons per kilowatt, warranted pulling the pump rods. They wanted to renew the pump leathers if the slippage was serious and, yet, they did not want to shut down the pump and pay for pulling the rods if the yield was normal. Was their decision in favor of meters for these other two wells justified?

The larger city had problems rather different from those of the smaller as its location on an inland river made filtered river water much cheaper and softer than that available for deep wells. Like so many other water plants, this plant was not a new one designed for this city's 1930 to 1940 population. It had been enlarged and improved little by little until it consisted of a combined steam and electric pumping station and a generally modern filtration plant.

The usual rate of flow controllers, flow indicators and loss of head gages had been installed on the old and new filters, and a master meter had been placed on the individual discharge of each of the last two electric high lift pumps. These meters furnished much valuable data on pump conditions, consumption rates, and pumping costs.

No meters had originally been installed on the large compound steam pumps, and any pumpage reports were subject to an unknown percent of error due to a guess at slippage. Due to that error, the condition of pump valves was assumed to be satisfactory until their

poor condition was evident; suspected leaks in the distribution system could not be proven unless located, and no accurate means was available to compare costs of steam and electric pumping.

Steam turbine and motor driven low lift pumps required an even greater approximation to arrive at capacity and efficiency figures. Filters were washed at rates determined by guess due to the lack of a meter on the wash water line. In the boiler room, too, the judgment of the engineer and the intuition of the firemen were depended upon to safeguard needless waste of the coal pile. With the present low electric power rates a moderate size steam pumping plant must take advantage of every saving in order to keep the cost per gallon pumped at a figure comparable with efficient electric pumping.

This larger city superintendent and his consulting engineers figured and approximated and guessed and investigated so frequently, whenever they wanted to know the whys of some pump or filter or consumption performance, that they determined to find some way to eliminate so much uncertainty.

It was found that many large plants and a surprising number of smaller water works, were being operated on a very definite basis. This was possible because dependable master meters furnished definite data and chart records of rates of flow, total pumpage and exact time of starting and stopping each unit. Not only was this information accurate and complete, but it made it possible to adjust pumps, filter devices and mains immediately when a loose valve or worn or clogged impeller cut down pumpage, when filter operation was out of proper balance, or when pumpage exceeded consumption by excessive amounts.

Were these men justified in pushing through the request for completely metering their plant, to change their guesses to facts, and to make surprising savings by more efficient operation?

The experiences of those two cities are probably quite similar to the problems that confront every water works man. Would you solve your problems by installing reliable master meters on the discharge lines from wells and high lift pumps as did these two cities? A visit to any group of efficiently operated water plants will reveal well and pump lines equipped with master meters.

Let us consider for a moment the wells from which so many small cities derive their water supply. Of the many reasons for metering the pumpage from each well, three are particularly outstanding and result in three distinct and often large savings. After all, it is the

direct return in savings that justifies investment in any kind of equipment.

As in the case of the smaller of the cities just referred to, the yield of all well pumps ultimately falls off due to wearing of the plunger leathers, or the wearing of turbine impellors and rings, or other allied causes. The condition of well pumps is always a mystery unless accurate means are provided for measuring the rate of pumpage discharge. Motor operated pump jacks and motor driven turbine pumps will maintain about a uniform speed and a uniform power consumption regardless of the slip through the pump. Unless the pumpage is actually measured there is no way of knowing if the pump is delivering full capacity or only a part of its capacity. Two of the direct savings made by a master meter result from eliminating this guessing about the pump's condition. If the rate of pumpage has fallen off, much can be saved from the power bill by pulling the pump and placing it in perfect condition. If this rate of pumpage is normal, much can be saved by avoiding the expensive and delaying pulling of the pump when it was not necessary. The third direct saving made by master meters, is to give a constant check on the difference between water pumped into the mains and that sold to customers through individual meters. If this loss is excessive, a real saving will result from knowing and stopping leaks. Should this loss suddenly increase, the meter would be the cause of a large saving by immediately indicating a sudden and hidden leak. Even though cities may be small, savings from these three sources and from many others would pay for the meters in a surprisingly short time.

Most larger cities repump their treated water supplies or their untreated supplies, from one or more high lift pumping stations. Every city has its individual arrangement and problems, but the value of metering the high lift pumpage is appreciated by every one. Displacement pumps are subject to slippage from worn valves, broken valve springs, and packing difficulties. Centrifugal pumps decrease in efficiency from wearing of impellors and accessory parts. Here again pumping costs may be reduced by repairing any unsatisfactory conditions which would have continued undetected without the aid of the constant indication, the computed total and the graphic chart record of the discharge of each pump.

Superintendents and engineers of average and large sized cities frequently wish to know the relative flows through the several arterial mains supplying various sections of their distribution system. Often

two or more large mains will extend from the pumping station, or from the reservoir, to a central district. To plan for future demands of the system the flows through the present feeders should be accurately known. While a survey may be made with portable flow meters at intervals of a few years, much more knowledge will be obtained by maintaining a permanent flow meter on each of these arterial feeders.

Surprising conditions have been revealed by tests on the flows in such parallel feeder mains. One pipe line has occasionally been found to carry nearly the total flow while the others carried but little of the load. In such cases the regulation of a controlling valve or two has permitted each main to carry its share. Meters on such lines would pay for themselves many times over if their records made adjustments possible, which saved the expensive installation of an additional feeder.

Greatest care is exercised by every water superintendent to know the location of every valve and if it is open or closed. That is easier said than done. A master flow meter on each of the few arterial mains supplying definite sections of the city furnishes a constant check on the flows through these lines and catches at once any incorrect valve closing. In case of suspected large leaks these meters furnish immediate knowledge of the district to be investigated.

The proper operation of filtration plants demands an accurate knowledge of rate and duration of flows in a variety of lines. Raw water flow determines the amount of chemicals to be supplied. Rate of flow through each individual filter and the corresponding loss of head determine proper time for filter washing. Of these flows and various other indications demanded by the filter plant operator, probably none is receiving the special attention today that is being given to the rate of filter wash. Apparently many of the recently designed plants, and a few notable ones in particular, are being equipped with a flow meter on the wash water line. Instead of leaving the responsibility for correct washing to the assumed original capacity of the wash water pump and to the best guess of the operator, the superintendent knows from his meter chart the exact rate at which each filter is washed. More than that, he knows the length of time each was washed and the time of day and the amount of water thus used. Such a flow meter insures the proper washing of filters and also serves to reduce materially the cost of treatment by conserving unnecessary waste of filtered wash water.

It might be worth while to mention the two distinct types of meters and the three styles of one of these types. The two types are "displacement" and "differential pressure" meters. The displacement meter is available in many makes and styles and in various sizes up to a rather definite limit. The common house service meter is by far the greatest application of this type, although some fairly large displacement meters are in use on large services and even on pumping lines.

The differential pressure meters have been used on most of the larger lines and for measuring the discharge of pumps. These meters may be grouped in three classes depending upon the method used to develop and measure the differential pressure which is proportional to the flow. The Venturi Tube, the Orifice Plate, and the Pitot Tube, are the three familiar differential media. Each of these three, and some other modifications of these three forms, have their advantages in accuracy, cost, length of service and ease of installation. When planning a meter installation the relative merits of these styles should be considered as well as the relative advantages of the several widely known makes of meters which have a record of years of satisfactory service.

PRIVATE OPERATION OF SMALL CITY WATER SUPPLIES[1]

By G. C. Hyde[2]

In serving the smaller cities of Florida with an adequate water supply, we have adopted a general policy of securing the water from deep wells and, when practical, using centrifugal pumps installed in pits or on the surface, pumping the water direct from the wells to the city mains and stand pipes. This method is the most satisfactory for the following reasons, two or more pumps may be connected to one well, repairs are easily made, inspection is satisfactory and efficiency is higher than other methods. In old wells which cannot be adapted to the above arrangement, where the casings are too small to install coniflow pumps, we are using axiflow pumps with a booster pump at the top of the well connected to the same motor and shaft, which delivers water directly to the stand pipes and mains. We have found that the latter types of pumps are very satisfactory, but there is the necessity of inspection and general repairs every two or three years. All electric pumps are equipped with automatic pressure or float control starters which eliminate operators. No material trouble has been experienced with this equipment, if contacts are kept clean and regular inspections are made.

At some locations we have installed surface reservoirs for emergency purposes and have connected to them emergency motor and gas engine driven pumps; where steam is available, we are using emergency steam equipment. At all cities two or more wells are used and at some locations water is available from lakes or springs. Chlorinating equipment is installed when surface water is used for emergency purposes.

At some locations where ice plants are operated, the water is pumped directly from the wells through the ammonia condensers and drained to a surface reservoir, then pumped to the mains; this is a material saving in pumping costs for the combined plants and does not affect the water.

[1] Presented before the Florida Section meeting, April 3, 1928.

[2] General Superintendent, Florida Public Service Company, Orlando, Fla.

The depth of wells is as follows:

Eustis Section, 240 feet; Orlando, 940 feet; Lake Wales, 900 and 1218 feet and Avon Park, 900 feet. The diameter of well casings ranges from 6 to 20 inches.

At Lake Wales, although the bacterial count meets the requirements of the State Board of Health, the original well which had supplied pure water for a number of years, developed what appeared to be a vegetable growth. If allowed to settle in a quart jar, a white slimy substance would appear in the water and a disagreeable odor was noticeable. A new well was drilled approximately one mile away to a depth of 778 feet and the water produced developed the same condition. This well was then cased 15 inches to a depth of 140 feet and sealed, then cased 12 inches to the bottom and drilled to an additional depth of 440 feet, where a satisfactory supply of water was obtained producing 750 g.p.m. No cause was found for the contamination of the supply, but it is believed that it was due to drainage wells or seepage from lakes. It is my opinion that drainage wells must be eliminated or the under ground water supply in Florida will be contaminated to an extent which will require using surface water with filtration and treating plants for city supply.

Our rates for fire hydrants average as follows:

2 inches	$15.00 per year
4 inches	25.00 per year
6 inches	35.00 per year
8 inches	50.00 per year
10 inches	65.00 per year

We endeavor to secure a fire hydrant for every 400 feet of main. The gross income per year for all fire hydrants at the six properties amounts to $16,182.00 for a total of 463 hydrants, or an average income of $34.95 per hydrant. From the above figures it is readily seen that the revenue from fire hydrants does not meet the carrying charges on extra sizes of mains, emergency pumping equipment and the allocation of charges in total plant investment necessary for this class of service. We believe that the water department is entitled to an average higher revenue per hydrant. A practice has been adopted of using 6 inch pipe where hydrants are served on a run and 4 inch on a loop.

Our rates average for domestic consumers:

Gallon rate

First	5,000 gallons	@ 40 cents per thousand gallons
Next	5,000 gallons	@ 30 cents per thousand gallons
Next	15,000 gallons	@ 20 cents per thousand gallons
All over	25,000 gallons	@ 15 cents per thousand gallons

Cubic foot rate

First	1,000 cubic feet	@ $2.50 per thousand
Next	2,000 cubic feet	@ 2.25 per thousand
Next	2,000 cubic feet	@ 2.00 per thousand
All over	5,000 cubic feet	@ 1.50 per thousand

Minimum charges average $1.25 per month

The investment of the Florida Public Service Company as of December 31, 1927, in the water utility, was $1,300,000.00. The total operating revenue for 1927 was $116,158.55. The operating expenses are $52,586.13. The net income was $63,572.42. The operating ratio was 45.2 per cent, which shows a return on the investment of 4.89 per cent. We are, therefore, not elated over our earnings, but we are keeping in mind that a large portion of our investment has been made and additional revenues may be obtained without excessive expenditures. The total number of services is 3955.

The above figures should not be taken as the results which might be obtained by larger plants or by small plants where no other utilities are operated. We can combine our labor expenses in plant operation, of course, and many men employed in the water department perform other duties, but a division is kept of their time.

We feel that the water utility is a very hazardous business, especially from having the underground supply contaminated or shut off by the caving-in of wells and the possibility that in the near future it will be necessary to secure the supply from surface sources and to install filtration and other treatment plants.

BACTERIAL RESULTS FOLLOWING A FAILURE TO STERILIZE NEW WATER MAINS

By W. M. Olson,[1] and H. L. Wright[2]

A great deal has been written concerning the advisability of and methods for the sterilization of water mains just after laying.[3] It is the purpose of this paper to present results of bacterial analyses which show the effect in one village of a failure to perform such sterilization.

GENERAL

Data presented below are the results of an investigation of a municipal water supply by the Department of Health. The public water supply, serving a village of 800 population, is obtained from a deep drilled well of proper location and construction, is stored in a 50,000-gallon pneumatic tank and, except as noted below, is distributed through a system of cast iron pipe mains. "There is no sanitary sewer system. Private septic tanks are connected to miscellaneous groups of tile lines which discharge at various points."[4]

Early in the year 1926, the distribution system was extended to serve a rapidly developing section of the village about one-half mile west of the original town. A few houses in this section had been served by a 2-inch galvanized pipe line laid by a real estate operator. This line was continued in service.

In June, 1926, a rural public health nurse telephoned me that the water in the new section of the village was undrinkable and that she was being deluged with complaints. Our inspection

brought out the fact that while the village water is safe at the source, it has been temporarily polluted in an outlying section of town by careless procedure dur-

[1] Sanitary Engineer, Cook County Department of Health, Chicago, Ill.

[2] Health Director, Cook County Department of Health, Chicago, Ill.

[3] Journal Am. Water Works Assn., Vol. 15, No. 1; Vol. 17, No. 1; Vol. 18, No. 1; Water Works, October, 1927, p. 406.

[4] Report on Public Water Supply, Cook County Department of Health, July 1, 1926.

TABLE 1

Results of bacteriological analysis

DATE	SAMPLE NUMBER	LOCATION OF SAMPLE	BACTERIA PER CUBIC CENTIMETER		B. COLI IN			PROBABLE B. COLI PER 100 cc.	REMARKS*
			20°C. gelatin 48 hours	37°C. agar 24 hours	10 cc.	1 cc.	0.1 cc.		
1925									
November 17	178	School	4	2	5−	1−	1−	0	O
1926									
June 3	A	Jennings	—	150	5+	1+	1−	250	G†
June 17	347	Kinney	10,000	6,800	5+	1+	1+	3,000	N
	348	Jennings	2	7	5−	1−	1−	0	G
	349	Tank	12	4	1+4−	1−	1−	2	O
	350	Steffan	2	4	1+4−	1−	1−	2	O
June 28	351	Kinney	—	70	5+	1+	1−	250	N
	352	Hughes	—	50	5+	1+	1+	3,000	N
	353	Jennings	—	23	5−	1−	1−	0	G
	354	Hansen	—	10,000	5+	1+	1+	3 000	N
July 20	374	Raney	10	2	5+	1−	1−	38	N
	375	Hughes	21	2	5+	1+	1−	250	N
	376	Hansen	12,000	—	4+1−	1−	1−	15	N
August 17	424	Hughes	170	800	5+	1+	1+	3,000	N
	425	Kinney	200	550	5+	1+	1+	3,000	N
	426	Hansen	700	1,000	5+	1+	1+	3,000	N
1927									
March 24	448	Raney	11	4	2+3−	1−	1−	5	N
	449	Hughes	10	5	3+2−	1−	1−	9	N
	450	Hansen	11	4	5−	1−	1−	0	N
	451	School	750	275	3+2−	1−	1−	9	O
April 5	24138	Cleveland	—	6	5−	1−	1−	0	O‡
	24139	School	—	3	5−	1−	1−	0	O‡
	24140	Schmidt	—	4	5−	1−	1−	0	O‡
June 16	453	School	—	27	2+3−	1−	1−	5	O
	454	Raney	—	0	5−	1−	1−	0	N
	455	Hughes	—	0	1+4−	1−	1−	2	N
September 20	490	Yunkel	—	0	5−	1−	1−	0	N
	491	School	—	0	5−	1−	1−	0	O
	492	Raney	—	0	5−	1−	1−	0	N

*O, on old main; G, on galvanized iron "main;" N, on new main.

† Forty-eight-hour presumptive test by Elizabeth M. Arentz Clinical Laboratory, Joliet.

‡ Engineering Laboratory, Illinois Department of Public Health.

ing and after the recent construction of water pipe extensions when new pipe lines were laid across low-lying swampy ground. On June 17, the trench . . . . was observed to be still open and partially filled with water. The effluents from three private septic tanks was noted to leak directly into this trench. It is reasonably to be expected that many of the open trenches were polluted by septic tank effluent and the surface wash from privies. . . . . It is possible that the newly laid pipes were not flushed with sufficient thoroughness. At any rate, it is certain that no attempt was made to sterilize the mains after laying.[5]

Following this inspection, it was recommended to the Village Board of Trustees, in charge of the water system, that "All newly laid

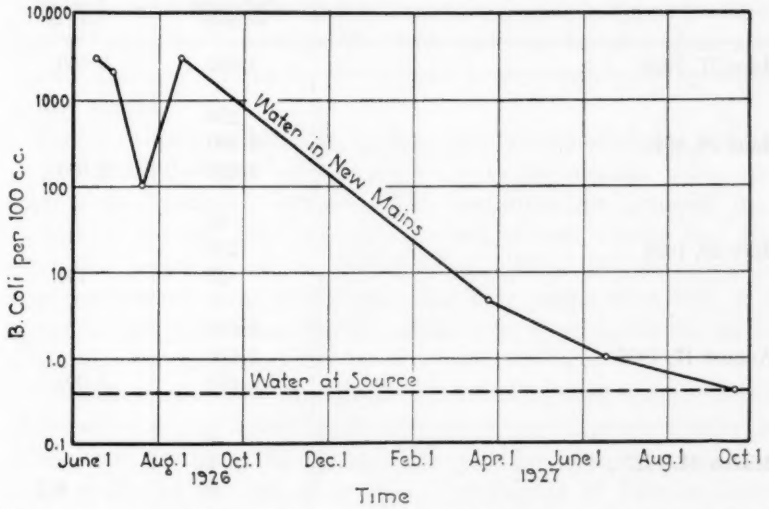

FIG. 1. CHANGE IN B. COLI CONTENT IN NEW MAINS WITH LAPSE OF TIME

water mains should be thoroughly flushed." Some flushing was done, following this recommendation, but in general, the tendency was not to "waste" much water in this way. As a result, a long period of time was required for the new pipe lines to be cleared of excessive contamination.

While our investigation was in progress, additional water pipe was being laid in the southwest portion of the village. It is believed that this work had little, if any, effect upon the results reported below.

[5] Ibid.

RESULTS

Samples of water were taken from time to time. Bacterial analyses reported below, except as otherwise noted, are the results of completely confirmed tests in accordance with standard methods in the laboratory of the Sanitary District of Chicago. These analyses

TABLE 2

Quality of water in new mains

DATE	B. COLI PER 100 CC.	
	Individual samples	Average for day
June 17, 1926	3,000	3,000
June 28, 1926	250	
	3,000	
	3,000	2,083
July 20, 1926	38	
	250	
	15	101
August 17, 1926	3 000	
	3,000	
	3,000	3,000
March 24, 1927	5	
	9	
	0	4.7
June 16, 1927	0	
	2	1
September 20, 1927	0	
	0	
	0	0

were made under the supervision of C. C. Ruchhoft, Bacteriologist, through the courtesy of E. J. Kelly, Chief Engineer.

Samples were taken from faucets at various locations as noted in table 1. "B. coli per 100 cc." is reported as "the most probable number" obtained from a McCrady table. Under "Remarks" the sampling points are classified as being either on an old water main,

on a newly laid main, or on the galvanized iron "main" which is an old "main." The "School" and "Schmidt's" are on an old main about half way between the water source and the new development. All other "old main" samples were taken near the source. "Jennings" on the galvanized iron "main" is right in the new development.

B. coli values for sampling points on new mains are summarized in table 2.

An average B. coli value for "water at the source" was taken to be 0.4 which is the mean of the eleven samples numbered 178, 348, 349, 350, 353, 24138, 24139, 24140, 490, 491 and 492.

Data in table 2 are plotted on a logarithmic scale in figure 1. Since the "0" value for September 20, 1927, could not be plotted on such a scale, this was arbitrarily plotted as 0.4, the mean value for water at the source.

Figure 1 shows an initial sharp drop in contamination due perhaps to makeshift flushing, followed by a rise to the original value, and then a slow gradual decrease. The contamination dropped to 1 B. coli per 100 cc., the Treasury standard, almost exactly one year after the beginning of the investigation. Since the investigation was commenced some weeks after the new mains were laid, it is apparent that more than twelve months were required for the initial contamination to disappear.

The risk assumed by the village in permitting such contamination of the water was obviously great and entirely out of proportion to the difficulty of sterilizing the mains, which could have been accomplished quite easily by the use of a little hypochlorite of lime or liquid chlorine.

CONSTRUCTING WATER MAINS ON BRIDGES[1]

By G. G. Routledge[2]

Details which require consideration in connection with the construction of a water main on a bridge are as follows:

The size of the main should be ample for present and estimated future requirements, for a reasonable period of time.

As the pipes are likely to be subject to vibration, and stresses considerably greater than they would be underground, they should be of wrought iron or steel with special attention given to their protection from rust and tuberculation.

The openings in the bridge abutments for the pipes should be large enough to permit the pipes being passed through them and leave sufficient space for insulation.

Scaffolding usually secured to bridge members will, in most cases, be necessary for the construction of the pipe line, and where possible, should be permanent for pipe inspection and repairs.

In some cases the most convenient method of getting the pipes into position is to pass them through the openings in the abutments and then move them on rollers on the scaffold. In others it will be more convenient to hoist them onto the scaffold from some point below the bridge.

Bridges on which pipes have to be placed, vary so much in design that the best method of supporting the pipes also varies very considerably.

In some cases, brackets supporting the sidewalk provide convenient supports for the pipes; in others, the pipes can be suspended with iron rods or bars from the floor beams or attached to other bridge members.

It is advisable to have two supports to each pipe, so that in the event of a failure at a joint, the pipe itself will be securely held in position.

[1] Presented before the Canadian Section meeting, March 9, 1928.

[2] Superintendent of Water Distribution, Toronto, Canada.

PIPE JOINTS

Up to the present, only two kinds of joints for connecting pipes together on bridges have been used in Toronto, viz., the ordinary screw coupling joints, and joints with flanges either screwed or welded onto the ends of the pipes and bolted together.

The screw coupling joints have been found a little more difficult to make water-tight than joints with flanges, but when they have been made water-tight they have remained so, and they have the advantage over flanged joints inasmuch as they offer no difficulties to the installation of insulating materials.

Flanged joints permit of a pipe being taken out of the line and replaced with another one much more easily than with screw coupling joints, but in these days any defects in the line would most likely be repaired by welding rather than by the replacement of a whole length of pipe.

As both of these joints are practically rigid, it is advisable to install a special joint to permit of movement due to longitudinal expansion and contraction of the pipes.

The temperature of the water will control that of the pipe, and as the range will rarely exceed 40°F., the maximum change in a pipe length of 20 feet will be about $\frac{1}{16}$ inch.

The ordinary stuffing box type of expansion joint has been found quite satisfactory.

The material of which the bridge is constructed will generally be subject to a range of temperatures two or three times that of the pipe, and will result in movement at the points where the pipe is attached to the bridge, and possible disturbance of the insulating materials at these points.

This can be avoided by making each pipe joint an expansion joint, and make unnecessary the special expansion joint referred to above.

USING "VICTAULIC" JOINTS

On the new Glen Road Bridge, at present under construction in Toronto, one-half of the 12-inch pipes required there will have "Victaulic" joints, which will permit of movement, without leakage, considerably greater than that resulting from changes in temperature.

Practically no trouble has been experienced with the joints of pipes on bridges, but there has been trouble with pipes and joints immediately outside the bridge abutments, due to settlement of the fill.

Lead joints in spigot and socket pipes have been found preferable to flanged joints at these locations, as they are more flexible.

Clamps, made of half round iron driven into the face of the caulked lead and firmly tightened on the pipe with bolts and set screws, prevent the blowing of lead joints where a pipe is displaced permanently due to settlement of a fill, or temporary displacement in some ground under heavy moving loads, such as at railway crossings.

LOCATION OF AIR VALVES

In most cases the construction of a pipe line on a bridge results in a high spot where air may accumulate.

Automatic air valves and ordinary 1-inch connections with gate valves have been used for the removal of air at the high points, and these have given more trouble, especially the former, than any joint or other fitting on a bridge.

The high spot is usually at the centre of a span and in a position difficult of access for inspection or repairs. In some cases a manhole in the floor of the bridge can be constructed to provide access, but in most cases it will have to be reached from below with ladders or scaffolding.

In order to find the velocity of water necessary to remove air from a high point in an 8-inch pipe, an experiment was made with a 5 foot 6 inch length of 8-inch pipe laid horizontally, and connected with elbows to the tops of a vertical 8-inch inlet pipe and a vertical 6-inch outlet pipe. The inlet and outlet pipes were each about 8 feet in length. At the lower end of the 6-inch pipe a valve was placed and used to control the rate of flow.

The static pressure on the supply mains at the point was about 75 pounds, and an air compressor was used to displace the water in the horizontal pipe and about half of the vertical 8-inch inlet pipe.

Several tests were made and each one indicated that an average velocity in the 8-inch supply pipe of 1.7 feet per second removed all air from the pipes.

In the opinion of the writer, excepting in the case of a large steel pipe, with a thin shell, which might collapse under a vacuum, any advantages there may be in having an automatic air valve on a bridge are more than offset by the difficulties in protecting and maintaining it in working order.

It would, however, be desirable to have an air-cock installed at the high point, if it could be easily protected and made readily accessible for operation.

PROTECTION FROM FROST

Where there are freezing temperatures and the possibility of low rates of flow through the pipe at the same time, it is necessary to encase the pipe with some insulating material.

Where the minimum rate of flow is considerably above that required to prevent freezing at the lowest temperature, it is also necessary that the pipe be insulated to prevent damage to it during a forced shut-down at low temperatures, unless some means can be adopted which can be absolutely depended on to have the exposed pipe promptly de-watered.

Even if such means can be adopted, it is very undesirable that water, probably already at a low temperature, should have its temperature still further lowered by its passage through an unprotected pipe.

In Toronto some pipes on bridges are protected with sawdust contained in a square wooden box surrounding the pipe.

The frames to which the $\frac{7}{8}$-inch tongue-and-groove pine flooring boards forming the box are nailed, are spaced about 2 feet apart, and are of a size just sufficient to allow the boards to clear the flanges of the pipe.

This provides a minimum thickness of sawdust of about 3 inches at the sides and top and bottom of the pipe.

The sawdust must be kept dry, and in order to accomplish this, where the box is exposed to the weather or where water is likely to get on the top of it, the top is covered with sheets of galvanized iron, clinch-jointed together, and dressed down the sides for a distance of about 4 inches.

Another method of protection consists of strips of wood about 1 inch in width and $\frac{1}{2}$ inch in thickness, placed longitudinally against the outside of the pipe about 3 inches apart and held in position with $1\frac{1}{2}$-inch strips of galvanized iron at intervals of about 2 feet. Around these strips of wood, strong canvas is wound, and around the canvas 2 inches of mineral wood is placed and encased in sheets of galvanized iron secured by galvanized sheet iron clamps about 1 foot apart.

The last three pipes constructed on bridges in Toronto were surrounded with two 1-inch layers of hair felt; the methods of application varying only slightly from the following particulars:

1. Surround the pipe and fittings with a heavy asphalt felt, secured with jute twine wound spirally with 3-inch spacing.

2. Apply a coat of asphalt at a temperature of 212° Fahrenheit.

3. Apply a layer of insulating felt 1 inch in thickness, secured with heavy jute twine wound tightly and spirally at 1½-inch spacing.

This forms one complete layer and is repeated in the same order and manner for other layers which are considered necessary.

After the last coat of 1-inch insulating felt has been applied, it is surrounded by heavy asphalt felt as in No. 1, and coated with hot asphalt as in No. 2.

A jacket of either metal or heavy asphalt roofing is then applied, sealed with an asphalt sealing compound, and secured with separate rings of pure copper wire, galvanized wire or galvanized metal straps spaced about 4 inches apart.

The pipe should be insulated where it passes through the bridge abutment and for a short distance beyond the abutment where temperatures and rates of flow are likely to be very low.

Each complete layer is about 1¼ inches in thickness, and it is estimated that four such layers, or a total thickness of 5 inches around the pipe is required to protect it for six hours at 25° to 30° below zero F. when there is no movement of water in the pipe.

In the opinion of the writer, the last mentioned method of insulation is much preferable to either of the other two.

As the possibility of having to shut down a water main for a longer period than six hours is always present, it is, therefore, necessary where there may be freezing temperatures, to provide means for immediately dewatering all the pipes on the bridge section in such emergencies.

It is advisable to have a gate valve on the main near each end of the bridge, and in most cases the chambers enclosing these will provide good places for connections for dewatering purposes.

MAINS OVER STEAM RAILWAYS

Where a pipe has been constructed over a steam railway with not much more than the required 22 feet 6 inch clearance above the rail, and especially where there is a considerable amount of shunting, trouble has been experienced in maintaining the insulation due to gasses, steam and hot cinders being shot against it from the locomotives.

An outer jacket of galvanized sheet iron has lasted only a short time in such locations, and it has been found that copper sheets secured with copper wire, provide a more secure protection and in the end are cheaper.

In connection with the use of copper, it is worth while bearing in mind that its value is sometimes sufficient to induce some people to remove it without permission.

Not long after a 22-inch main had been installed on a bridge, a a length of about 400 feet of pipe was found to have been stripped of the copper wire, leaving the outer jacket of the insulation held in position by the jointing compound only. As the pipe was well above the steam railway, it was rewound with galvanized wire instead of copper wire.

INSPECTION EVERY THREE MONTHS

An inspection of all pipes on bridges is made once every three months.

Where a new bridge is to be constructed and a water main required thereon, it is necessary that the bridge engineer be consulted so that suitable accommodation for the water mains may be included in the design and perhaps arrangements made for its construction before the bridge floor is laid.

Where it is possible, it is very desirable that all public services required on a bridge should be located so that one permanent scaffold could be constructed and available for inspection and maintenance work.

Where a water main is required on a new bridge or an existing one, it is necessary to secure permission from all parties having jurisdiction over the bridge.

DISCUSSION

THE CHAIRMAN: We are very glad to have this information from Mr. Routledge, and I would like to ask if he has had any experience with protective material other than galvanized iron or copper. Has he ever tried a very heavy asbestos paper?

MR. ROUTLEDGE: No, we have never tried that. All that we have had has been galvanized iron or copper.

MR. E. V. BUCHANAN: Do you prefer to lay your pipe under the river bed or across the bridge?

MR. ROUTLEDGE: That depends a great deal on just how difficult it is to place it under the bed of the river. We have had practically

no trouble with our mains on bridges, except in the few cases I have mentioned. One can easily imagine that in some cases it would be much more easily done by going under the bed of the river.

MR. HODKINSON: When you lay the pipes under the floor of a bridge, and you have to shut off the water in cold weather, what happens?

MR. ROUTLEDGE: It would freeze if it is very cold weather, and that is what the protection is for, to protect the pipes from freezing until we have time to de-water them. When a pipe is shut down during freezing temperature, we have to take immediate steps to de-water it.

MR. HODKINSON: We have pipes laid under the river bed, and the only trouble that we have is in grading the river bed for the laying of the pipes. Sometimes we have trouble in spring floods, owing to trees and other material coming down with the ice.

MR. ROUTLEDGE: When there is any freezing temperature we have to drain the pipes, but in the summer time it is not necessary.

MR. HODKINSON: The pipes will freeze even when you have them insulated.

MR. ROUTLEDGE: Yes, I would not like to trust them even with insulation. It is merely protection against freezing for sufficient time to permit the pipe being de-watered.

MR. E. M. PROCTOR: In The Journal, November, 1927, there were quite a series of tests as to how long it took to freeze water in a water main with certain types of insulation. The tests were made in New York, where they have to bring the water service across the subways, and where it is often exposed in open places of buildings. The pipes have to cross these open spaces, and they must be insulated. There are nearly a dozen different kinds of insulation. The tests were made in a refrigeration plant, where they can get whatever temperature desired.

I have had to deal with laying water mains in the north country, some of them running over fields, and we went into that question to

see what could be done, and we found out some very remarkable facts.

The Gypsum Company manufacture an article that we used. We found that a 6-inch water main, with 8 inches of gypsum around it, would stand seventy hours at an outside temperature of twenty degrees below zero.

A MEMBER: With no flow?

MR. PROCTOR: Yes, with absolutely no flow of water. The Gypsum Company have circulars to prove that they are right, and they are going to carry out a test this winter in one of the cold-storage plants in Toronto. In putting in a water system for a small town in the north country, where there are heavy rock cuttings, something has got to be done, because it is impossible to cut through the granite rock a sufficient distance to get below freezing. We have taken a 24-inch light pipe and put a cast-iron pipe in the middle of it The insulation is mixed like mortar and the bottom part of the pipe is poured first, and then the top part afterwards. The upper half is left open until it is dry. The material must be kept dry. After the work is completed, it must be sealed up tight. The theory is that the latent heat is retained in the water and then it does not freeze.

In the last few years, in connection with refrigeration plants, they have worked out some formulas as to the value of insulation material, and they have some most remarkable data as to how long you can leave water in a water main without freezing. I do not think that we would have any trouble if we had eight inches of this insulation around the pipe. They say that it can be left for eighty hours without any danger of freezing.

MR. E. V. BUCHANAN: We have had some discussion in London in connection with the freezing of meters during the winter. One of our commissioners made an experiment a couple of years ago. He took an ordinary milk bottle, filled it with water, sealed it up, and covered it with two inches of ordinary material that is used on water heaters; he then set this milk bottle out in the back yard in the middle of the winter; in the spring he took it in and pried open the asbestos and he found that the water had not frozen. That seems very remarkable to me, but he tells me it is a fact, and I believe him. I question very much the advisability of using these expensive materials for insula-

tion if an extra thickness of some cheap material, such as sawdust, will fill the same purpose.

MR. WILSON: It is a question in my mind whether it is worth the expense to make boxes for putting these pipes in and filling them with sawdust. We have several cases in Ontario where pipes are laid across bridges, absolutely without covering, and I have not known of any cases where they have been damaged by freezing. There were cases in Galt, Belleville and Pembroke. In Pembroke the pipe is carried right over the top of the girders of the bridge, and I have never heard of a single case where these pipes have frozen up. We had a pipe across a long bridge in Brantford, and it was supposed to be shut off every winter, but for two or three winters it was not shut off, and we never had any freezing of the water in that pipe. We had one break in a main that went across a bridge and was absolutely imbedded in concrete; the main burst and we had to take it all out.

With regard to the latent heat in water, we had a rather interesting thing in a 20-inch main. It varied from 6 to 3 feet from the surface. It was originally put in at 6 feet, but they re-graded the road in some places, and in one spot it was only 2 feet 9 inches from the surface. We can tell after a slight snowstorm whether there is a leak in that pipe, because where we see a big bare spot on the pavement after a slight snowfall, we know that there is a leak in that main, and we take it up and repair it.

MR. ROUTLEDGE. I think that it is very much better to have the pipes insulated. They are all right as long as there is a movement of the water, but as soon as they are shut off, they will freeze in a very short time. We had a main in Toronto that was not protected, except with sawdust in a wooden box. It happened to be shut off and all the pipes on the bridge were destroyed. It was a 12-inch main.

In order to determine, as nearly as I could, what rate of flow is necessary in a main in order to prevent freezing, I tried one short length of 6-inch pipe. I had a ½-inch lead pipe entering that and a ½-inch lead-pipe outlet. I started at first on a flow of about 0.45 gallon per minute, and it kept running away for some time. Although that pipe was not protected, I got it down to 0.16 gallon per minute, and the pipe froze with a temperature about four above zero. Some of the men said it would be the small pipe that would freeze first, and

in order to ascertain that I had another ½-inch pipe laid along side of the 6-inch one. We started them both at 0.1 gallon per minute, and when the temperature dropped to four below, one end of the 6-inch pipe broke, but the small ½-inch pipe was still running.

As long as there is a flow of water—and evidently not a very large one is required—it will prevent freezing. Certainly, I think, that, when a pipe is running over or under a bridge, it should be protected, because you never know when you may have to turn the main off for hours, and unless you have means that you can rely on for de-watering the main very rapidly, insulation is necessary.

MR. WILSON: I can quite understand why the small main did not freeze as rapidly as the big one. You had a greater flow in proportion in the small pipe.

STUART, FLORIDA, IRON REMOVAL AND PUMPING STATION[1]

By P. P. De Moya[2]

The problems to be met in the design of the Stuart iron removal and pumping station are the same that tax many communities in Florida today. They are:

1. To rid the water of iron.
2. To operate and carry all fixed charges on the operating water revenue (a thorn in the side of most water works.)

Stuart, a city of 4500 population, is located in Martin County, on the east coast of Florida, 39 miles north of West Palm Beach. It is on a peninsular bounded on three sides by the St. Lucie, a tidal river. A salt water stream or creek forms, substantially, the fourth boundary. In effect, the city is surrounded by salt water. This small area definitely limits the maximum rate of supply from the wells within it if infiltration of salt water is to be avoided.

The source of supply is from three 6 inch wells, 60 feet deep, located on the pumping station site within a radius of 200 feet. An ice plant, immediately southeast of and adjacent to the pumping station, pumps from wells of the same strata as our own. This water is used for cooling water over surface condensers. They use about 250 g.p.m. We use this water in order to conserve the ground supply. The quality of the well water was found to be satisfactory in every respect except for its extremely high iron content.

Mr. Malcolm Pirnie, of Hazen & Whipple, New York, made very complete and thorough tests and experiments at Stuart, during the latter part of 1926, in order to determine the most suitable method of removing the iron from the water.

Using the corrugated metal roof of an adjoining warehouse as an aerating surface and two 16-inch tiles for filters, various periods or degrees of aeration were tried with various depths and grades of gravel as filter beds until the proper combination was definitely established to accomplish the complete removal of the iron. The iron content of

[1] Presented before the Florida Section meeting, April 4, 1928.

[2] Manager, Consumers Water Company, Stuart, Fla.

the water before aeration and filtration ranged between 3.6 and 12.9 p.p.m., a highly objectionable quantity. After proper aeration and filtration, only a trace of iron could be found. The U. S. Treasury Department sets 0.3 p.p.m. of iron as the upper limit in potable waters.

The explanation of the chemical and physical reactions that take place is shown by Mr. Pirnie as follows:

> The ground water carried iron in the form of a soluble ferrous bi-carbonate and, also, an excess of free carbon dioxide. During aeration the bulk of carbon dioxide escapes. When there are salts of calcium in the water, as there are here, a change in the condition of the iron follows aeration, i.e. the iron changes from the ferrous to the ferric state and a part appears as a finely divided insoluble iron hydrate, but a portion of the iron still remains in solution as ferrous carbonate which more gradually changes into the insoluble iron hydrate and free carbon dioxide when in contact with the particles of iron hydrate in the water. The problem is to hasten the change of this remaining soluble iron to the insoluble form and to remove this from the water. In order to do this most efficiently, and to employ gravity to assist in holding down the insoluble iron, the aerated water is passed upward, at a uniform rate, through a properly graded bed of gravel. In the filter, the water comes into contact with millions of square feet of gravel surface onto which the iron hydrate sticks in porous masses. When the soluble ferrous carbonate comes into contact with this iron hydrate, it is converted by physiochemical reaction into ferrous oxide and free CO_2. The ferrous oxide is retained in the bed and the free CO_2 passes upward with the water. The water on top of the contact bed is therefore free from iron but contains the carbon dioxide which was formerly part of the ferrous carbonate.

The water in question, having an original alkalinity of about 146 p.p.m., is not materially affected by the slight addition of CO_2 and no aeration of the filtered water to release this free CO_2 is provided other than that which the water receives in falling over the weirs in the filter walls into the clear well. The CO_2 content of the well water is 24.5 p.p.m., of the aerated water about 8 p.p.m. and of the water on top of the filter beds 9 p.p.m. The color of the water from clear wells runs from 7 to 15 p.p.m., using platinum cobalt salt indicator standards. The water is highly satisfactory for all domestic, commercial, industrial and public purposes. Formerly it was unfit for use in the laundry, it stained porcelain, made sidewalks or fountains unsightly and was extremely disagreeable to taste.

In its essentials, the experimental plant was duplicated in the design of the present iron removal plant. The filters and clear well are located in the east end of the station. There are three (3) filters, each 6 feet wide by 11 feet 6 inches long by 11 feet deep. The clear

well is in the extreme east end of the plant and is 18 feet 8 inches wide by 20 feet long and 11 feet deep. The roof over the filters and clear well is reinforced concrete. This roof, with a 9 foot louvre fence around its parapet, is the aerating basin or spray pond. The filter control gallery is immediately west or in front of the filters. The pump room occupies the west end of the building. The building of reinforced concrete frame and cement blocks, is 24 feet wide and 79 feet long.

The three wells, of our supply system, are joined in a common suction header. The water from the ice plant condenser pan is run by gravity to a 16 inch well casing, with sealed bottom, extending 22 feet below the level of the ground. A 6 inch suction extends 20 feet into this well casing and connects to the common suction header. This arrangement automatically prevents pulling on the wells as long as sufficient water is coming over from the ice plant and equalizes the pull so that the wells make up any deficiency between the flow from the ice plant and the demand of the low lift or spray pumps.

Two low lift pumps each of 210 g.p.m. capacity are located on the common suction header. They discharge through aerating nozzles on the roof of the filter room previously described. Provisions in building and principal piping provide for the addition of another or third pump as may be required through increased demand. They are direct connected motor driven centrifugal pumps, of 5 h.p. each. These pumps are kept in prime at all times, automatically, by means of an extremely simple and dependable combination of tried and proven equipment. The try-cock on the top of each pump casing, was replaced with a steam pump governor, and connected into the bottom of a vacuum tank. The level of water in the vacuum tank is maintained through a short range, by a Hytor vacuum pump, with float switch control, the float being in the vacuum tank. The balanced valve of the steam governor, is kept open by the spring in its operating mechanism, until the pump is put in operation, when the pressure developed by the pump on its discharge side and conducted to the top of the piston in the operating mechanism, closes the valve, and cuts the pump off from the vacuum tank, until the pump is automatically shut down. When the pump is automatically shut down, the balanced valve, with its pressure on the closing side relieved, and actuated by its spring, opens, and the pump and its suction lines are again directly connected into the vacuum tank with its water level constantly and automatically maintained at an elevation above

the tops of the pumps. It will be seen that the priming system is a combination flooding and vacuum type, automatically serving either function as changing circumstances may require. In addition both pumps are sealed at the glands with a water line from the distribution system, so that the glands are effectively sealed even when one or both low lift pumps are idle. The operation of the low lift pumps is controlled by float switches placed in the clear well. One pump normally supplies the city, but should the demand exceed the capacity of one pump for a sufficiently long period, the water level in the clear well will drop to the cut-in point of the second pump, and both will continue to operate until the clear well is again filled when both will shut down.

We now have the well water pumped by the low lift pumps to the aerating pond on the roof. The aerated water runs from the spray pond by gravity to a basin at the lower end of the pond, and is evenly distributed by three vertical 16 inch flumes to the bottom of the three upflow filters. Through gridiron piping in the bottom of the filter beds, the aerated water is evenly distributed. The water passes upward through the bed, and over a sharp crested weir in the filter well, and discharges into the clear well.

Two high lift, 200 g.p.m. centrifugal pumps, direct connected to $7\frac{1}{2}$ h.p. electric motors, deliver the filtered water from the clear well to the distribution system on which is floating a 60,000 gallon elevated tank, located on the pumping station site. The distribution system consists of $7\frac{1}{2}$ miles of cast iron mains, and is a circulating or gridiron system.

The high lift pumps like the low lift are operated automatically. They are controlled by two float switches in the elevated tank. When the water level falls 18 inches, the first high lift pump immediately cuts in to keep up with the demand. Should the demand be such that the capacity of one pump is insufficient, and the water level in the tank drop 36 inches, the second high lift pump will then cut in. Were the aerial tank far removed from the pumping station, a diaphragm switch might have been used. Since one low lift pump and one high lift pump is sufficient to take care of the city's normal demand, it will be seen that the depreciation and wear and tear on this one battery would greatly exceed that of the second battery that remains idle. To combat this condition a simple system of double throw switches permits the daily alternation of the battery of pumps that will serve that day. In this way the depreciation wear and tear on the pumps and motors are evenly distributed.

The new station has been in operation since the first of December.

The filter beds accumulate amounts of iron in direct proportion with the iron content of the water filtered. This accumulated iron precipitate increases the resistance of flow through the filters. This

FIG. 1. STUART IRON REMOVAL AND PUMPING STATION, EXTERIOR VIEW

resistance or loss of head is reflected in the rising elevation of the water in the-vertical flumes on each of which is a water gauge.

To rid the bed of this accumulation, they are rapidly flushed to waste every second day of their operation. Experience over a period of five months shows that this down flush suffices to keep the water level in the flume below the top of the gauge glass for a period

of two months. Once in about two months, then, it was found necessary to give each filter a vigorous up wash to waste at the rate of 10 gallons per square foot per minute.

The head causing flow, recorded December 9, 1927, was 8 inches. A rapid down flush reduced this head. On each second day following the

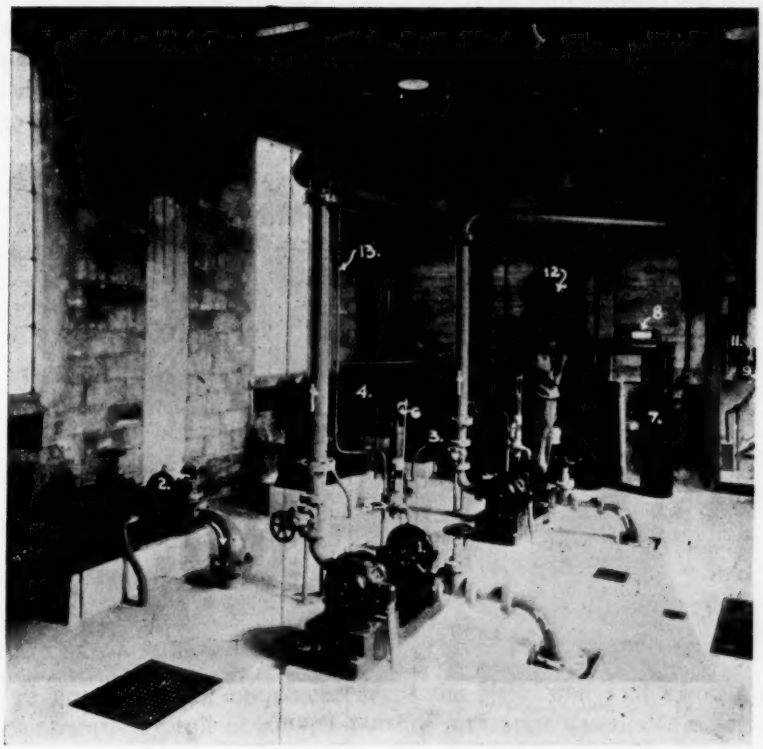

FIG. 2. STUART IRON REMOVAL AND PUMPING STATION
(PRIOR TO COMPLETION, NOVEMBER, 1927)

1, low lift pump; *2*, high lift pump; *3*, vacuum pump; *4*, vacuum tank; *5*, vacuum line; *6*, vacuum valve (automatic steam pump governor); *7*, stilling well; *8*, recording instrument; *9*, filter; *10*, filter gallery; *11*, clear well; *12*, loss of head gage; *13*, air relief lines.

head causing flow, observed just before down flushing, was somewhat higher and, on February 28, 1928, it was 62 inches. A pressure up wash was given the filters and on the second day following their return to operation, the head causing flow was again 8 inches.

Down flushing, to waste, is controlled by a quick opening valve in the flushing line. The depth of water over the beds is approximately 2 feet. The down flush is continued until the level of the water in the filter is just even with the top of the bed. The flush valve is then closed and the filter then filters to waste over the wash water weir until the effluent runs perfectly clear. The wash water outlet valve is then closed and the water rises in the filter until the edge of the filtered water flow weir is reached and then the water pours over this weir into the clear well. The flow weir, 12 inches long, is 6 inches higher than the wash water weir which is 63 inches long. So that on

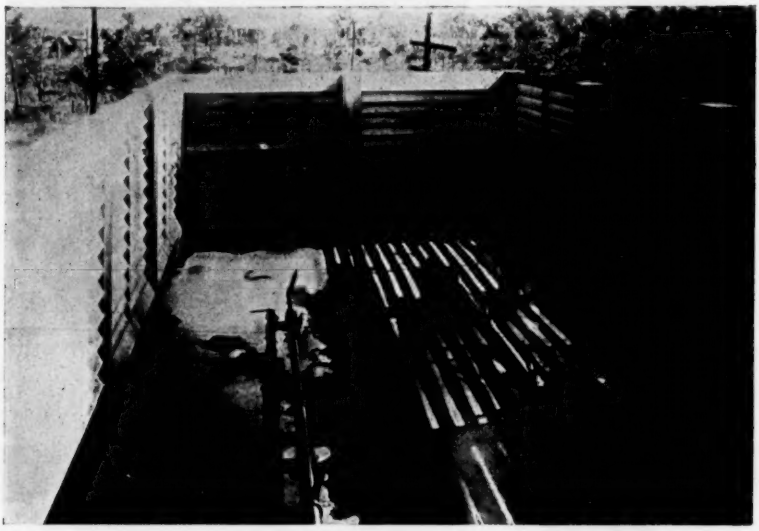

FIG. 3. SPRAY POND

one chart 12 inches wide and 24 hours long, the stage of water on both weirs is recorded. The length of each weir is sufficient to prevent the stage on either exceeding 6 inches for any condition of operation.

The elevation of the water in each filter is brought through a 2 inch pipe to a separate stilling well in the pump room. The level of the water in each stilling well is recorded for every minute of the day by separate Gurley recording instruments. The charts have two zero lines for stage, one the edge of the wash water weir and the second, 6 inches above the first, the edge of the flow weir.

A supplementary attachment on each instrument affords guide lights for the operator when pressure up washing. When the stage of water over the wash water weir is such that the predetermined flow of wash water is passing over the weir, a green electric bulb in front of the operator lights. If the flow increases beyond this desirable point a red light lights and the operator backs down on his hydraulic valve operating valve until the red goes out and the green relights. This prevents needless waste of water which might otherwise occur.

Each chart, changed daily, gives the executive in charge a complete, accurate and permanent record of the operation of each filter.

The chart accurately records the period during which one or two spray pumps were delivering water to the filters, whether this water was going to the clear well or to waste, its rate and quantity. They clearly show when each filter was down washed and for how long and the amount of water wasted in the process. In pressure upwashing they show the duration and rate of the wash and water wasted.

From the foregoing it will be seen that, by means of labor saving devices, in the form of automatic equipment, this plant operates extremely successfully with the aid of one man's time an average of 3 hours per day. In this time he cleans up, oils the pumps and motors, and changes the weir charts. On alternating days he down washes the beds. This man devotes the balance of his day to running services and maintaining the distribution system. A night operator is not needed. With the exception of the three hours in the morning, the plant is alone and is operating with far greater accuracy automatically than manually, with its doors locked, the balance of the twenty-four hours.

Since automatic equipment keeps the clear well and stand pipe comparatively full at all times a fire protection feature is reflected in the city's insurance rating. On the sound of the fire siren two men, the operator and the executive immediately go to the station, and stand by for the duration of the fire.

I have used the word automatic rather promiscuously, but I believe there is no doubt that the Consumers Water Company has truly an automatic water plant that will be but the beginning of numerous others in Florida. The principles involved can be successfully applied to plants far larger, and cities whose water demands would make a pigmy of Stuart.

The entire connected electric load of this plant is $25\frac{3}{4}$ h.p. and the

output capacity of the plant, with its present equipment, a half million gallons of filtered water per day.

The successful operation of this automatic pumping station is prefaced on dependable central station power and periodic, but positive, inspection by the operator. Since our state is now covered with a network of transmission lines supplying dependable and cheap power, the water plant can now come out of the red and occupy its rightful place on the black side of the ledger.

A WATER SAMPLER FOR THE DETERMINATION OF DISSOLVED OXYGEN

By Jack J. Hinman, Jr.[1]

A number of sampling devices have been invented for the collection of specimens of water for the determination of dissolved oxygen. All work on the same principle, namely, the siphoning through a small sample bottle of a quantity of water equal to several times the capacity of the bottle in which the specimen is ultimately to be collected. The purpose of this procedure is, of course, to insure a reasonably representative sample and to sweep out any oxygen which the bottle may contain or which may adhere to the walls of the bottle.

Many of the samplers, as that devised by Hale and illustrated on page 78 of Whipple's Microscopy of Drinking Water, 4th edition, 1927, have consisted of exposed glass bottles with fragile connections. Others such as the Harvard type, illustrated on page 196 of the book above referred to, and the University of Illinois form, described in Bulletin 16 of the Illinois State Water Survey Division, are much more rugged, but are rather expensive.

In the conduct of work on the determination of dissolved oxygen in surface waters the writer has frequently been annoyed by the breakage of glass sampling apparatus. In supplying equipment to students of the sanitary examination of waters it was desirable to have several sets of equipment for collecting specimens. The Harvard and Illinois forms seemed somewhat too expensive for the purpose.

An attempt was made to use tall specimen jars carrying large rubber stoppers about 3 inches in diameter through which glass tubes and a post for a spring clip were passed. The spring clip was to hold the sample bottle in place. A wire was twisted about the top to act as a handle. These collectors functioned satisfactorily enough, but the jars were sometimes broken on rocks and floating ice.

It was therefore decided to have the tinner make some cylinders of

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galvanized iron carrying ears through which a rope sling might be passed. A top was made of galvanized iron with a flare such that the diameter of the lower edge was about ½ inch greater than the diameter of the upper edge of the cover. A section of old inner tube was then

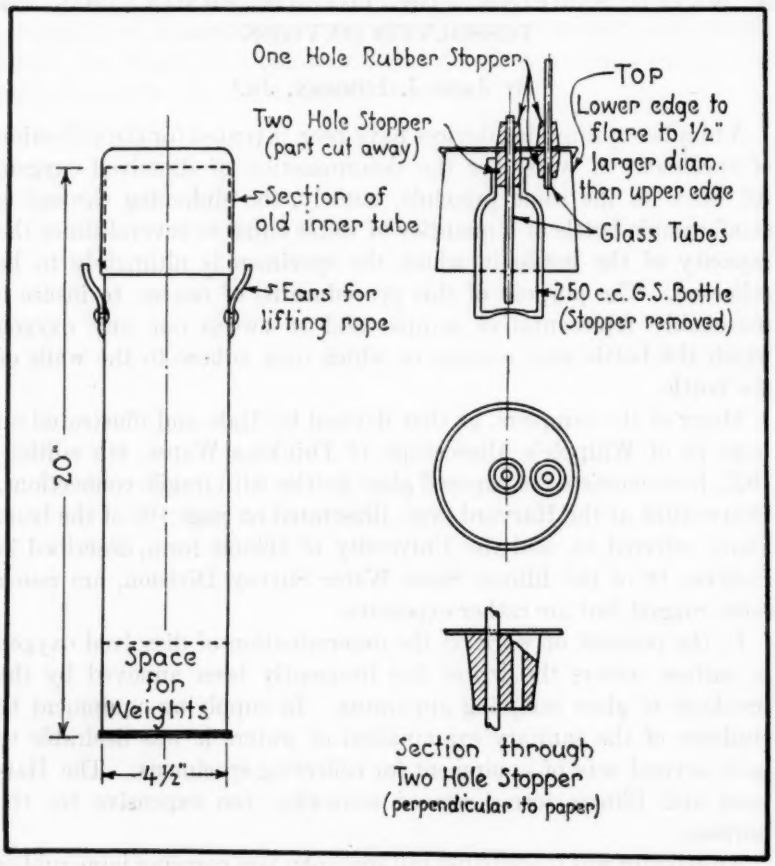
One Hole Rubber Stopper
Top
Lower edge to flare to ½" larger diam. than upper edge
Two Hole Stopper (part cut away)
Section of old inner tube
Glass Tubes
Ears for lifting rope
250 c.c. G.S. Bottle (Stopper removed)
20"
Space for Weights
4½"
Section through Two Hole Stopper (perpendicular to paper)

FIG. 1. SAMPLER FOR DETERMINATION OF DISSOLVED OXYGEN

(Material—Galvanized iron. Seams to be turned and soldered.)

slipped over the cylinder in such a way that about ½ inch projected over the edge of the metal and about 3 inches were in contact with the cylinder. When the flared top was pushed down on the cylinder, the rubber made a tight joint. All seams in the apparatus were turned and soldered so that it was then air-tight.

A hole $\frac{3}{8}$ inch diameter was made in the center of the top of the cover and another hole of the same size was placed midway between the first hole and the edge of the top. Two $\frac{1}{4}$ inch glass tubes were then cut off about 6 inches long and the edges fire polished. Four rubber stoppers of the size fitting the 250 cc. glass stoppered sample bottles were then selected and slipped onto the tubes as shown in figure 1. These stoppers held the tubes firmly in place when pressed tightly together with the metal of the top between them. The stopper on the underside of the top was expected to fit the sample bottle and was a two hole stoppper instead of a one hole stopper as were the others. A part of this stopper was cut away near the top so that air and water could escape from the sample bottle during filling. The way in which this stopper was cut away is well shown in the sketch. When the first pieces of apparatus were made, a third hole was put in the metal of the top through which a common binding post was inserted and to which a spring clip was fastened. It was found, however, that the rubber stopper was ordinarily enough to hold the sample bottle in place.

The glass tubes are inserted in such a way that the center tube passes nearly to the bottom of the sample bottle and the top of it is cut off close to the top of the securing upper stopper. The other glass tube is inserted so that its lower end is nearly flush with the bottom of the lower securing stopper, while the top of the tube projects 3 or 4 inches from the top of the cover. This arrangement insures the proper direction of flow in filling the container.

A length of 20 inches and a diameter of about $4\frac{1}{2}$ inches have been selected for the cylinders. Weights may be placed in the bottom of the cylinder to sink it when a specimen is to be collected. Such weights may consist of lead poured into the bottom, pieces of iron or rocks. While the lead would be easiest to handle, it is sometimes more convenient to use rocks or material which can be obtained at the point where the sample is to be collected. In such cases the weight to be carried to the spot may be a material consideration. A cylinder of the length given contains nearly a gallon and a quarter which is sufficient capacity to allow for the volume of the necessary weights and yet fill the sample bottle more than ten times as the water enters and fills the cylinder.

It has sometimes been found that the height of the cylinder interfered with its use in shallow streams. By bending the outlet tube and turning the cylinder on its side with the outlet tube pointing upward the difficulty may be reduced.

Breakage of the glass tubes, especially the outlet tube, has sometimes occurred. These tubes are easy to make and to insert and it is easy to carry a couple in the pocket for such emergencies. They could be made of metal, if desired.

Loss of the cover has occurred on one or two occasions. This too may easily be avoided. A hole in the edge of the cover may permit its being tied by a cord to one of the ears of the cylinder.

In practise the apparatus has worked well. It has been in use among the students in the writer's classes for several years and its simplicity has enabled it to endure the roughest service.

TYPHOID FEVER IN THE LARGE CITIES OF THE UNITED STATES IN 1927[1,2]

A special effort has been made during the past year to obtain data previously missing from our tables. Through the courtesy of the health officers of twenty-two cities, many of the gaps have been filled. The spaces still remaining are in most cases due to the fact that data are unavailable in the records of the health departments. The figures recently obtained have been incorporated in the general tables as well as added to the individual records of the cities.

Three cities appear in these summaries for the first time—Elizabeth, N. J., Erie, Pa., and Oklahoma City, Okla.—making a total of eighty-one cities, all of more than 100,000 population.

The New England cities (table 1) have continued remarkably free from typhoid, the combined rate for the twelve cities of this group being even lower in 1927 (1.26) than in 1926 (1.51) and continuing, as in 1926, to be the lowest rate for any group of cities in the country (table 13). The highest rate in this group in 1927 was 3.3, as against 4.9 in 1926.

New Haven and Springfield, in 1927, for the first time in their histories, report no typhoid deaths. Cambridge, which had six typhoid deaths and the highest rate of any city in this group in 1926, had only one typhoid death in 1927. On the other hand, Worcester, which had only one typhoid death in 1926, had six in 1927; New Bedford also shows considerable excess over the previous five-year average. Of the seven cities with 1926 rates under 1, three (Springfield, Providence and Bridgeport) had also 1927 rates under 1. No city had a rate under 1 for all of the three last years.

The single typhoid death in Providence was of a child, aged 2

[1] Reprinted from the Journal of the American Medical Association, 90:20, May 19, 1928, p. 1624.

[2] The preceding articles were published Jour. Amer. Med. Assoc., May 31, 1913, p. 1702; May 9, 1914, p. 1473; April 15, 1915, p. 1322; April 22, 1916, p. 1305; March 17, 1917, p. 845; March 16, 1918, p. 777; April 5, 1919, p. 907; March 6, 1920, p. 672; March 26, 1921, p. 860; March 25, 1922, p. 890; March 10, 1923, p. 691; Feb. 2, 1924, p. 389; March 14, 1925, p. 813; March 27, 1926, p. 948, and April 9, 1927, p. 1148.

months, whose father had had typhoid two years before; the mother and two other children were carriers.

In the Middle Atlantic states (table 2), two cities (Paterson and Yonkers) report no typhoid deaths in 1927. It is a proud record for Yonkers that this is the second consecutive year without a typhoid death and the fourth such year in its history, the typhoid record being completely clear also in 1920 and 1922. Yonkers is the only large city in the country to have had a rate of 0.0 more than once (table 10). On the other hand, the two other cities of this group with no typhoid deaths in 1926 (Albany and Utica) have the highest rates in the whole

TABLE 1

Death rates of cities in New England States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1915	1906–1910
New Haven	0.0	2.2	4.4	6.8	18.2	30.8
Springfield	0.0	0.7	2.0	4.4	17.6	19.9
Providence	0.4	0.7	1.8	3.8	8.7	21.5
Bridgeport	0.6	0.6	2.2	4.8	5.0	10.3
Cambridge	0.8	4.9	4.3	2.5	4.0	9.8
Lynn	0.9	3.8	1.6	3.9	7.2	14.1
Boston	1.1	1.8	2.2	2.5	9.0	16.0
Hartford	1.8	1.2	2.5	6.0	15.0	19.0
Fall River	2.3	0.8	2.3	8.5	13.4	13.5
Lowell	2.6*	0.9	2.4	5.2	10.2	13.9
Worcester	3.1	0.5	2.3	3.5	5.0	11.8
New Bedford	3.3†	0.7	1.7	6.0	15.0	16.1

* Population figures furnished by the health department, 112,759.

† Population figures furnished by the health department, 121,460.

group in 1927. Camden, which has had the highest or next to the highest rate of the group every year since 1922 and the third from the highest in 1921, has the second lowest rate in 1927. Scranton and Rochester also have rates materially lower in 1927 than in 1926. The New York, Pittsburgh and Philadelphia rates have continued to fall, these three cities having in 1927 the lowest typhoid rates in their history. Buffalo, while having the third from the highest rate in this group in 1927, has halved its rate of 1926.

The two newcomers in this group, Elizabeth and Erie, are both well up to the average of the other cities. The serious epidemic in Erie in

TABLE 2

Death rates of cities in Middle Atlantic States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1915	1906–1910
Paterson	0.0	1.4	3.3	4.1	9.1	19.3
Yonkers	0.0	0.0	1.7	4.8	5.0	10.3
Camden	0.7	4.6	5.9	4.9	4.5	4.0
Scranton	0.7	4.2	2.4	3.8	9.3	31.5
Elizabeth	0.9*	1.0	2.4	3.3	8.0	16.6
Jersey City	1.2	1.9	2.7	4.5	7.2	12.6
Rochester	1.2	4.0	2.1	2.9	9.6	12.8
New York	1.3	1.9	2.6	3.2	8.0	13.5
Newark	1.3	1.5	2.3	3.3	6.8	14.6
Philadelphia	1.4	1.9	2.2	4.9	11.2	41.7
Erie	1.5†	0.8	2.3	6.9	49.0	46.6
Syracuse	1.5	1.1	2.3	7.7	12.3	15.6
Trenton	1.5‡	2.2	8.2	8.6	22.3	28.1
Reading, Pa	1.7	2.6	6.0	10.0	31.9	42.0
Pittsburgh	1.9	2.7	3.9	7.7	15.9	65.0
Buffalo	2.4	5.0	3.9	8.1	15.4	22.8
Utica	2.9	0.0	3.9§			
Albany	3.3	0.0	5.6	8.0	18.6	17.4

* Population figures furnished by the health department, 113,033.

† Population figures furnished by the health department, 131,000.

‡ The health department states that the diagnosis was doubtful in the two deaths that occurred.

§ Data for 1925 only.

TABLE 3

Death rates of cities in South Atlantic States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1915	1906–1910
Richmond	0.0	2.6	5.7	9.7	15.7	34.0
Norfolk	1.1	1.7	2.8	8.8	21.7	42.1
Baltimore	1.8	4.7	4.0	11.8	23.7	35.1
Washington	1.8	2.5	5.4	9.5	17.2	36.7
Wilmington	3.2	2.4	4.7	25.8*	23.2†	33.0
Jacksonville	7.2	8.8				
Atlanta	14.0	17.2	14.5	14.2	31.4	58.4

* 1916 only.

† Lacks 1913.

1911, although conspicuously affecting the five-year average 1911–1915 and presumably swelling the number of carriers in that community, does not seem to have had any very prolonged effect on the typhoid mortality.

In 1926 the highest rate in the group was 5.0; in 1927 it was 3.3. The average for all the cities of this section was 1.41 in 1927, as against 2.09 in 1926 (table 13).

TABLE 4

Death rates of cities in East North Central States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1915	1906–1910
Canton	0.0	3.6	3.3	7.0*		
Chicago	0.7	0.8	1.4	2.4	8.2	15.8
Milwaukee	0.9	1.7	1.6	6.5	13.6	27.0
Cleveland	1.0	1.4	2.0	4.0	10.0	15.7
Detroit	1.2	2.2	4.1	8.1	15.4	22.8
Indianapolis	1.3	5.4	4.6	10.3	20.5	30.4
Dayton	1.7	2.3	3.3	9.3	14.8	22.5
Grand Rapids	1.9	1.3	1.9	9.1	25.5	29.7
Columbus	2.0	1.7	3.5	7.1	15.8	40.0
Flint	2.1	0.7	4.6	22.7	18.8	46.9
Youngstown	2.4	0.0	7.2	19.2	29.5	35.1
Akron	2.8†	1.5	2.4	10.6	21.0	27.7‡
Toledo	2.9	4.7	5.8	10.6	31.4	37.5
Cincinnati	3.9	2.7	3.2	3.4	7.8	30.1

* Lacks data for 1916, 1917.

† Population figures furnished by the health department, 210,000.

‡ Data for 1909 and 1910 only.

Among the South Atlantic cities (table 3), the most striking record is made by Richmond, which had not a single typhoid death in 1927. Norfolk, which had a similar clear record in 1923, continues to show a consistently low rate. Baltimore and Washington have nearly as low rates as Boston and New York, an epidemiologic fact of considerable significance. As in 1926, Atlanta and Jacksonville show decidedly higher rates than the other cities in this group. The Atlanta typhoid death rate in 1927 ranks as one of the five highest among all the large cities of the country, as it has done every year since 1921. The rate for this group as a whole is much lower in 1927 (3.39) than in 1926 (5.38, table 13). In 1927, as in 1926, one

city in the East North Central states had no typhoid deaths (table 4). This city in 1927 was Canton, which the year before had the third highest rate in this group of eighteen cities; Youngstown, the city with no typhoid deaths in 1926, has in 1927 the fourth highest rate in the group. Indianapolis has a considerably lower rate in 1927 (1.3) than in 1926 (5.4). The highest rate in this group in 1927 is 3.9, as

TABLE 5

Death rates of cities in East South Central States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1915	1906–1910
Louisville	3.1	6.7	4.9	9.7	19.7	52.7
Birmingham	12.9	8.5	10.8	31.5	41.3	41.7
Memphis	14.5	19.2	18.9*	27.7	42.5	35.3
Nashville	16.0	35.0	17.8	20.7	40.2	61.2

* The Memphis typhoid death rate for 1924 was erroneously stated in the summary for that year. In the average for 1921–1925 this error has been carried along up to the present. The old five-year average is here corrected.

TABLE 6

Death rates of cities in West North Central States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1916	1906–1910
Kansas City, Kan	0.0	4.3	5.0	9.4	31.1	74.5*
Minneapolis	0.7	1.4	1.9	5.0	10.6	32.1
Omaha	0.9	1.8	3.3	5.7	14.9	40.7
St. Louis	1.9	2.3	3.9	6.5	12.1	14.7
Duluth	2.7	0.8	1.7	4.4	19.8	45.5
St. Paul	2.8	1.2	3.4	3.1	9.2	12.8
Kansas City, Mo	2.9	3.5	5.7	10.6	16.2	35.6
Des Moines	3.3	2.7	2.2	6.4	15.9	23.7

* Lacks 1906, 1907.

against 5.4 in 1926. The combined rate for this section is slightly lower in 1927 (1.31) than in 1926 (1.69, table 13) and is about the same as the rate for the New England cities (1.26), which is the lowest sectional rate in the country.

The very low rate of Chicago for the last two years (0.7, 0.8) is noteworthy, being about half the rates for New York City (1.3) and for Philadelphia (1.4).

TABLE 7

Death rates of cities in West South Central States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1915	1906–1910
Fort Worth	4.3	10.7	6.1	16.3*	11.9	27.8
Houston	5.6†	6.0	7.6	14.2	38.1	49.5‡
San Antonio	5.7	7.8	9.3	23.3	29.5	35.9
Oklahoma City	6.4§					
Dallas	6.6	8.9	11.2	17.2		
El Paso	7.9	9.2	10.8	30.7	42.8	
New Orleans	8.0	18.6	11.6	17.5	20.9	35.6
Tulsa	8.7	14.3	16.2#			

* Lacks data for 1918 and 1919.

† Population figures furnished by the health department, 284,446.

‡ Data for 1910 only.

§ Population figures furnished by the health department, 140,000.

Lacks data for 1921 and 1922.

TABLE 8

Death rates of cities in mountain and Pacific States from typhoid per hundred thousand population

	1927	1926	1921–1925	1916–1920	1911–1915	1906–1910
San Diego	0.9*	0.9	1.6	7.9	17.0	10.8
Spokane	0.9	6.5	4.4	4.9	17.1	50.3
Los Angeles	1.0†	1.1	3.0	3.6	10.7	19.0
San Francisco	1.7	2.5	2.8	4.6	13.6	27.3
Portland, Ore	2.1‡	2.5	3.5	4.5	10.8	23.2
Oakland	2.2	0.8	2.0	3.8	8.7	21.5
Salt Lake City	2.2	0.7	6.0	9.3	13.2	41.1
Seattle	2.7	2.3	2.6	2.9	5.7	25.2
Denver	2.8	3.5	5.1	5.8	12.0	37.5
Tacoma	2.8	3.8	3.7	2.9	10.4	19.0

* Population figures furnished by the health department, 115,300.

† Population figures furnished by the health department, 1,200,000.

‡ Population figures furnished by the health department, 332, 835.

TABLE 9

Death rates from typhoid in 1927

Honor roll (from 0.0 to 2.0 deaths per hundred thousand)

Canton	0.0	Boston	1.1
Kansas City, Kan	0.0	Norfolk	1.1
New Haven	0.0	Detroit	1.2
Paterson	0.0	Jersey City	1.2
Richmond	0.0	Rochester	1.2
Springfield	0.0	Indianapolis	1.3
Yonkers	0.0	New York City	1.3
Providence	0.4	Newark	1.3
Bridgeport	0.6	Philadelphia	1.4
Camden	0.7	Erie	1.5
Chicago	0.7	Syracuse	1.5
Minneapolis	0.7	Trenton	1.5
Scranton	0.7	Dayton	1.7
Cambridge	0.8	Reading	1.7
Elizabeth	0.9	San Francisco	1.7
Lynn	0.9	Baltimore	1.8
Milwaukee	0.9	Hartford	1.8
Omaha	0.9	Washington	1.8
San Diego	0.9	Grand Rapids	1.9
Spokane	0.9	Pittsburgh	1.9
Cleveland	1.0	St. Louis	1.9
Los Angeles	1.0		

First rank (from 2.0 to 5.0)

Columbus	2.0	St. Paul	2.8
Flint	2.1	Tacoma	2.8
Portland	2.1	Kansas City, Mo.	2.9
Oakland	2.2	Toledo	2.9
Salt Lake City	2.2	Utica	2.9
Fall River	2.3	Louisville	3.1
Buffalo	2.4	Worcester	3.1
Youngstown	2.4	Wilmington	3.2
Lowell	2.6	Albany	3.3
Duluth	2.7	Des Moines	3.3
Seattle	2.7	New Bedford	3.3
Akron	2.8	Cincinnati	3.9
Denver	2.8	Fort Worth	4.3

Second rank (from 5.0 to 10.0)

Houston	5.6	Jacksonville	7.2
San Antonio	5.7	El Paso	7.9
Oklahoma City	6.4	New Orleans	8.0
Dallas	6.6	Tulsa	8.7

Third rank (above 10.0)

Birmingham	12.9	Memphis	14.5
Atlanta	14.0	Nashville	16.0

The East South Central cities (table 5) continue to have the outstanding high typhoid rates of the country. These cities and their closest competitors, the West South Central cities, had about the same rates in 1925 (14.30, 13.27), but in 1927 the West South Central average was 6.71 as against the East South Central rate of 10.07 (table 13). The latter rate is nevertheless a great improvement over the 1926 average of 14.47.

In 1927 Louisville, with its rate of 3.1, stands quite by itself, the three other cities of the group having rates well over 10. Only one other large city in the United States (Atlanta) had such a rate in 1927, Birmingham had rates under 10 from 1923 to 1926, inclusive, and Memphis had rates under 10 from 1920 through 1922; but only once since 1913 has Nashville had a rate under 10.

In the West North Central states (table 6), for the first time in these summaries, one city (Kansas City, Kan.) reports no typhoid deaths. The combined rate for the cities of this section (table 13) in 1927 (1.86) is lower than in 1926 (2.22), and the highest rate for an individual city reported in 1927 (3.3) is lower than the corresponding rate in 1926 (4.3). The range in 1927 of 0.0–3.3 is exactly the same range as in the New England and Middle Atlantic groups.

In the West South Central cities there is a notable improvement in the typhoid death rate in 1927, the combined rate for the group falling from 13.27 in 1925 and 11.69 in 1926 to 6.71 in 1927 (table 13). Every city in the group had a lower rate in 1927 than in 1926 (table 7). The most striking decreases since 1926 have been in New Orleans (from 18.6 to 8.0), Fort Worth (10.7 to 4.3) and Tulsa (14.3 to 8.7). Seven of the eight cities in this group fall into the second rank (table 9), having rates between 5 and 10, and the eighth city (Fort Worth) has about the same rate (4.3).

The cities of the Mountain and Pacific states have as a whole a slightly lower rate in 1927 (1.74) than in 1926 (1.98). The 1927 range of rates (table 8) was 0.9–2.8, as against 0.7–6.5 in 1926. The rate for Spokane dropped from 6.5 (seven deaths) in 1926 to 0.9 (one death) in 1927. In most of the cities in this group the 1926 and 1927 rates are running well below those of the preceding five-year average.

Seven of the eighty-one cities included in this summary had no typhoid deaths in 1927 (table 9). This is the largest number in a single year since these studies were started, a total of twenty-one such clear records having been reported from 1913 to 1927 (table 10).

TABLE 10

Occurrence of 0.0 typhoid death rates in the large cities of the United States

1919	Spokane	1926	Albany
1920	Yonkers		Utica
1922	New Bedford		Yonkers
	Providence		Youngstown
	Yonkers	1927	Canton
1923	Norfolk		Kansas City, Kan.
1924	Fall River		New Haven
	Hartford		Paterson
1925	Lowell		Richmond
	Scranton		Springfield
			Yonkers

TABLE 11

*Total typhoid rate for seventy-four cities, 1910–1927**

	POPULATION	TYPHOID DEATHS	TYPHOID DEATH RATE PER 100,000
1910	22,286,000	4,586	20.58
1911	22,916,700	3,883	16.94
1912	23,535,450	3,077	13.07
1913	24,151,936	3,222	13.34
1914	24,776,777	2,744	11.07
1915	25,392,422	2,373	9.34
1916	25,928,745	2,154	8.31
1917	26,528,213	1,963	7.40
1918	26,737,190†	1,796†	6.72
1919	27,373,579†	1,141†	4.17
1920	28,182,538	1,074	3.81
1921	28,509,732	1,130	3.96
1922	28,947,007	955	3.30
1923	29,580,000	936	3.16
1924	30,155,014	937	3.11
1925	30,938,501	1,067	3.45
1926	31,667,424	895	2.83
1927	32,492,123	638	1.96

* The following seven cities are omitted because data for the full period are not available: Canton, Dallas, Jacksonville, Oklahoma City, Tulsa, Utica, Wilmington.

† Lacks data for Fort Worth.

TABLE 12

Typhoid deaths that would have occurred 1910–1927 in the seventy-four cities of table 10 if 1910 rate had continued to prevail

YEAR	TYPHOID DEATHS AT 1910 RATE	EXCEEDING ACTUAL NUMBER OF TYPHOID DEATHS BY
1910	4,586	0
1911	4,716	833
1912	4,844	1,767
1913	4,970	1,748
1914	5,099	2,355
1915	5,227	2,854
1916	5,336	3,182
1917	5,468	3,505
1918	5,502	3,706
1919	5,633	4,492
1920	5,800	4,726
1921	5,867	4,737
1922	5,957	5,002
1923	6,087	5,151
1924	6,201	5,264
1925	6,367	5,300
1926	6,517	5,622
1927	6,686	6,048
	100,863	66,292

TABLE 13

Total typhoid death rate according to geographic divisions

	POPULATION, 1927	1927		1926		1925	
		Typhoid deaths	Typhoid death rate per 100,000	Typhoid deaths	Typhoid death rate per 100,000	Typhoid deaths	Typhoid death rate per 100,000
New England	2,540,209	32	1.26	38	1.51	58	2.37
Middle Atlantic	11,789,633	166	1.41	243	2.09	349	2.97
South Atlantic	2,244,300	76	3.39	120	5.38	117*	5.71*
E. North Central	8,319,500	109	1.31	137	1.69	174	2.19
E. South Central	854,300	86	10.07	121	14.47	111	14.30
W. North Central	2,520,400	47	1.86	55	2.22	81	3.31
W. South Central	1,698,946	114	6.71	173†	11.69†	180†	13.27†
Mountain and Pacific	3,508,435	61	1.74	68	1.98	73	2.19

* Lacks data for Jacksonville.

† Lacks data for Oklahoma City.

It does not approach, however, the condition in Great Britain, where (in 1924), out of forty-eight large cities, fifteen had no typhoid deaths during the year.[3] Thirteen of our eighty-one cities had 1927 typhoid rates of more than zero and under 1; twenty-three had rates between 1 and 2, making a total of forty-three cities on the Honor Roll (table 9). There are eight cities of second rank (all but one belonging to the West South Central group) and four of third rank, whereas in 1926 there were sixteen cities in these two ranks.

The total typhoid rate for seventy-four of the large cities for 1927 (table 11) is under 2 per hundred thousand of population, the lowest point yet reached. The rates since 1910 show a steady decline from 20.58 to 1.96, broken only by the very slight rises (the greatest increase of rate being 0.34) in the years 1913, 1921 and 1925. From the data of table 11, table 12 has been computed, which shows that had the 1910 typhoid death rate prevailed in these seventy-four cities up through 1927, there would have been 66,292 more deaths from typhoid than actually occurred.

Comparing the typhoid rates for the last three years in the different geographic sections (table 13), there has been a progressive decline in every group; 1925, however, was a "typhoid year." In 1927, five of the eight groups have typhoid death rates under 2. The other three groups have rates ranging from 3.39 to 10.07; the latter are all Southern groups.

[3] The deaths from typhoid in each city are those reported to us by the respective health departments. The rates have been calculated on the basis of the midyear 1927 population as estimated by the United States Bureau of the Census. In the ten instances in which such estimates were not available, the midyear population figures were furnished by the health departments of the respective cities.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN[1]

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Cover for Pipe End on Steep Slope Protects Workmen Inside. Eng. News-Rec., **99**: 1014, December 22, 1927. Brief description of wooden diaphragm used to cover end of penstock of Bucks Creek hydroelectric plant of Feather River Power Company during construction to protect workmen from objects inadvertently dropped into pipe. Cover, as designed, did not interfere with draft through pipe which was found desirable for carrying off smoke and dust and for maintaining low temperature during summer months.—*R. E. Thompson.*

Simple Design for Riveted Steel Penstock Wye. OSWALD SPEIR, JR. Eng. News-Rec., **99**: 1016, December 22, 1927. Brief illustrated description of simple wye dividing 80-inch pipe into two 54-inch laterals developed for Bucks Creek project of Feather River Power Co.—*R. E. Thompson.*

Wall Castings for Cast Iron Pipe. R. T. REGESTER. Eng. News-Rec., **99**: 1017, December 22, 1927. Tables of data on special castings, for use where cast-iron pipes pass through walls, to prevent leakage around pipes and breakage caused by settlement.—*R. E. Thompson.*

Flood Discharge Estimated for Winooski River. L. R. GROVES, JR. Eng. News-Rec., **99**: 1018, December 22, 1927. Brief data on discharge and velocity of Winooski River at Burlington, Vt., during November 1927 flood.—*R. E. Thompson.*

Holland Tunnel Driving Records. Eng. News-Rec., **99**: 1046, December 29, 1927. Headings of north tube met October 29, 1924, and headings of south tube met December 7, 1924. Check of alignment and grade was as follows, north and south tunnel respectively: line 0.30 and 0.29 foot; level 0.02 and 0.03 foot; distance 0.54 and 0.73 foot.—*R. E. Thompson.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

The Proper Methods Respecting Chlorination of Water Supplies. J. VAN BENSCHOTEN. Pub. Health J. (Can. Pub. Health Assocn.), **18**: 537–42, 1927. A general discussion of water chlorination. Chlorination of sewage is also discussed briefly.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Emergency Ventilator in Chlorinating Room. Eng. News-Rec., **100**: 9, January 5, 1928. Chlorination apparatus at Albany, N. Y., is located temporarily in room beneath sidewalk adjoining main pumping station. Air-tight door between station and chlorinating room and electrically-driven blower discharging to outside atmosphere, with starting switch in pumping station, have been installed for use in case of emergency.—*R. E. Thompson.*

New Water Works at Merritton, Ont. E. H. DARLING. Cont. Rec. and Eng. Rev., **41**: 242–5, December 28, 1927. An illustrated description of new water purification works at Merritton, treating Welland Canal water, which consists of mixing chamber, coagulation basin, 4 pressure filters of 1½ m.g.d. total capacity and chlorinating equipment. Former settling basin was converted into filtered water reservoir. Total cost was $66,300, filter equipment alone being $12,500. Instructions for construction were issued on February 1, 1927, and plant was in commission on April 23, i.e., in less than 12 weeks time. New intake, 18 inches in diameter in 18 feet of water, was constructed in 1926 owing to ice troubles with former intake, aggravated by prevailing low water.—*R. E. Thompson.*

Col. Potter Comments on Difference in Cost Estimate of Two Mississippi Flood Plans. Eng. News-Rec., **100**: 27, January 5, 1928. Comparison of estimates of War Department and of Mississippi River Commission, with comments, by Col. CHAS. L. POTTER, President of the Commission.—*R. E. Thompson.*

Removing Gases from Liquids. Akt.-Ges. für Stickstoff-Dünger. Brit. 245, 784, January 7, 1925. From Chem. Abst., **21**: 466, February 10, 1927. Oxygen and other gases are removed from boiler feed water by bringing water vapor into intimate contact with it at temperature and pressure which will avoid condensation.—*R. E. Thompson.*

New Water Supply Works for Aberdeen. Engineer, **142**: 545–8, 1926. From Chem. Abst., **21**: 467, February 10, 1927. Illustrated description.—*R. E. Thompson.*

Recent Influences on Boiler Water Treatment. J. D. YODER. Power Plant Eng., **30**: 1316–8, 1926. From Chem. Abst., **21**: 467, February 10, 1927. Use of tri-sodium phosphate in place of soda ash was not successful because of troublesome deposits and formation of sodium hydroxide. Presence of sodium hydroxide was probably due to reaction with calcium carbonate giving sodium carbonate. Correct ratio of sodium sulfate to sodium carbonate may be maintained by addition of small amounts of sodium sulfate or sulfuric acid.—*R. E. Thompson.*

The Iodine Content of Some Drinking Water and Some Other Waters in Belgium. CLINGUART. Bull. acad. roy. med. Belg. (5), **6**: 505–15, 1926. From Chem. Abst., **21**: 467, February 10, 1927. An application of method elaborated by VON FELLENBERG for drinking water in Switzerland (Biochem. Z. 139, 371, 1923; 152, 116, 1924 and C. A. 18, 2192). Belgian waters found to contain much more iodine than Swiss waters.—*R. E. Thompson.*

Problems in Pipe Lines and Water. N. D. WHITE. Am. Dyestuff Rept., **15**: 696–700, 1926. From Chem. Abst., **21**: 467, February 10, 1927. Items of experience with factory water supplies.—*R. E. Thompson.*

Apparatus for Purifying Water by Heating and Chemical Treatment. J. V. ROBERTS. U. S. 1,610,709, December 14. From Chem. Abst., **21**: 467, February 10, 1927.—*R. E. Thompson.*

Regeneration Zeolites. E. G. DUDEN. U. S. 1,611,422, December 21, 1926. From Chem. Abst., **21**: 467, February 10, 1927. Salt solution is supplied directly to zeolite underneath head of water and solution is drawn directly into and downward through zeolite without first removing raw water from tank used.—*R. E. Thompson.*

Apparatus for Feeding Sterilizing Reagents, etc., to Water Flowing in a Conduit. C. E. HILL. U. S. 1,610,283, December 14. From Chem. Abst., **21**: 468, February 10, 1927.—*R. E. Thompson.*

Standardization of Chlorinated Disinfectants. BERTA SAIKO-PITTNER. Pharm. Presse, **31**: 411–3, 1926. From Chem. Abst., **21**: 474, February 10, 1927. Discussion of experimental values obtained with various chloramines, when calculated on oxygen and chlorine basis.—*R. E. Thompson.*

Chloramines. C. H. H. HAROLD. Brit. 245, 820, October 7, 1924. From Chem. Abst., **21**: 476, February 10, 1927. Sterilization composition containing mono- or di-chloramine, or mixtures of these, is prepared by reaction of ammonia and chlorine in dilute aqueous solution. Usually, to obtain quantitative yields, solution containing only 12.5 p.p.m. ammonia is used, with addition of equivalent proportion of chlorine.—*R. E. Thompson.*

The Permeability of Portland-Cement Concrete. W. H. GRANVILLE. Engineering, **122**: 617, 1926. From Chem. Abst., **21**: 482, February 10, 1927. Factors affecting permeability of concrete when subjected to water pressure are: (1) influence of constituent materials, (2) effect of methods of preparing the concrete, (3) subsequent treatment. Some of the more important conclusions are: (1) Maximum strength corresponds with minimum permeability and minimum voids. Water ratio especially affects this property. (2) Mixes rich in cement are less permeable than leaner mixes. (3) Increase in sand at expense of gravel (with constant cement content) results in lower permeability. (4) Trowelling reduces permeability. (5) Aging in water results in lower permeability than aging in air. (6) Formula given which, it is claimed, represents approximately the law connecting permeability and

water content. (7) Procedure for permeability studies described.—*R. E. Thompson.*

Diesel Engine Exhaust Gas Observations. M. U. BUCHTING and G. DINKELA. Blast Furnace & Steel Plant, **14**: 459-60, 1926. From Chem. Abst., **21**: 484, February 10, 1927. Curves show how exhaust gas observations indicate any irregularities in Diesel engine operation. Carbon dioxide meter, based on principle of measuring difference in heat conductivity between air and carbon dioxide, is employed with Siemens and Halske copper-constantan thermocouples. Load of individual cylinders may be tested by means of gas analysis and measurement of temperature and deviations of normal operation of engine may be checked. Metering apparatus requires little attention and no experienced operator.—*R. E. Thompson.*

The Importance of the Surface Condition in Using Rust-Preventing Coatings. A. V. BLOM. Farben-Ztg., **32**: 351–3, 1926. From Chem. Abst., **21**: 503, February 10, 1927. Rust-preventing layers are created between surface of object and coating material when surface is treated with alkaline salts, oils or cement milk containing chromium compounds, red lead, lead suboxide, and other compounds, which, while entering into chemical combination with iron, form homogeneous film.—*R. E. Thompson.*

Sampling of Boiler Flue Gases. C. G. THATCHER. Power, **64**: 774–7, 1926. From Chem. Abst., **21**: 485, February 10, 1927. Gas from various sections of last pass of boiler may vary in carbon dioxide content from 10 to 15.5 per cent. Data on variations given.—*R. E. Thompson.*

Importance of Combustion Efficiency in Explosion Engines. PAUL DUMANOIS. Compt. rend., **183**: 592–4, 1926; cf. C. A., **20**: 1311. From Chem. Abst., **21**: 485, February 10, 1927. Economic efficiency of liquid fuels for explosion engines cannot be judged merely by calorific value; it is necessary to consider combustion efficiency under operating conditions, which depends on physical constitution of the mixture and on chemical properties as regards factors limiting compression in cylinder.—*R. E. Thompson.*

Different Methods of Softening Water Cause Unjustified Complaints About Toilet Soaps. C. STIEPEL and M. DITTMER. Z. deut. Oel-Fett-Ind., **46**: 738–9, 1926. From Chem. Abst., **21**: 507, February 10, 1927. When tap water is slowly added to a cooling 10 per cent soap solution, a slimy solution results which on further dilution separates a very bulky muddy scum (calcium soap) floating on clear water. When soap solution is added to large amount of water a finely divided precipitate of neutral calcium soap results, which remains suspended on still further dilution. The former phenomenon has given rise to groundless complaints about quality of toilet soaps.—*R. E. Thompson.*

Preventing Crystallization and Incrustation on Metal Surfaces. L. BLASS. U. S. 1,613,430, January 4, 1927. From Chem. Abst., **21**: 561, February 20, 1927. Boilers or other metal surfaces are subjected to action of magnetic

filed to prevent formation of crystals and deposition of incrustations on metal.—*R. E. Thompson.*

Physical-Chemical Determination by Seeded Precipitation; Application to the Determination of Lime Waters. MARCEL DUBOUX. Ann. chim. anal. chim. appl., **8**: 257–64, 1926. *See* C. A., **20**: 3196. From Chem. Abst., **21**: 547, February 20, 1927.—*R. E. Thompson.*

Chlorinating Water or Other Liquids. B. T. BROOKS. U. S. 1,613,438, January 4. From Chem. Abst., **21**: 617, February 20, 1927. Liquid chlorine is gasified by passing it in direct heat-exchanging relation to liquid to be chlorinated, and, after proper regulation and proportioning of flow of chlorine and liquid, chlorine gas is introduced into liquid. Apparatus described.—*R. E. Thompson.*

Purification and Other Improvements of Great Lakes Water Supplies. G. H. FENKELL. J. Western Soc. Eng., **31**: 413–39, 1926. From Chem. Abst., **21**: 617, February 20, 1927. Filtration at Detroit removes 67.6 per cent of B. coli and reduces turbidity from several hundred p.p.m. to 0.1 p.p.m. Filter capacity 35 per cent greater than average daily pumpage and 0.14 day's clear well storage capacity are most economical conditions for Detroit. Elevated tanks with capacity of 1.6 per cent of average daily demand reduce maximum demand on distributing pumps about 10 per cent and frictional loss through mains during time of maximum hourly demand about 20 per cent. Dual systems with over-chlorination of the industrial water and special treatment of domestic water discussed.—*R. E. Thompson.*

Oxygen Consumed, Chloride Content, and Chlorine Combinations in Water. W. OLSZEWSKI. Z. angew. Chem., **39**: 1309–10, 1926. From Chem. Abst., **21**: 618, February 20, 1927. Chlorination does not materially reduce oxygen-consuming capacity. Determinations either of chloride or of oxygen consumed alone are not sufficient for judging a water. Bacterial analyses are valuable in any case.—*R. E. Thompson.*

Effect of Hydrogen-Ion Concentration in Revivifying Zeolites. O. R. SWEENEY and RAY RILEY. From Chem. Abst., **21**: 618, February 20, 1927. Acidity or alkalinity of salt solution used to revivify has effect on some base-exchange materials. H-ion determinations of water softened can be used in control of softeners.—*R. E. Thompson.*

The Determination of the Hardness of Industrial Waters by Alkalimetry. CONSTANTIN BELCOT. Bull. soc. chim., **39**: 1648–52, 1926. From Chem. Abst., **21**: 618, February 20, 1927. In determination of permanent hardness some magnesium carbonate remains in solution, thereby making results too low. Therefore, $p = 2.8$ [n. cc. (0.1 N sodium hydroxide + 0.1 N sodium carbonate) − (n. cc. 0.1 N hydrochloric acid − $1000\,m/4.2$)], where p is actual permanent hardness as CaO; n. cc. denotes number of cc.; m is grams of magnesium carbonate dissolved; and $1000\,m/4.2$ is number of cc. of 0.1 N hydrochloric acid used to react with this magnesium carbonate. If iron is present

it must be removed by precipitation with ammonia, latter being driven off by evaporating to dryness.—*R. E. Thompson.*

Waters from Fish Hatcheries. F. T. SHUTT. Dept. Agr. Canada, Rept. Dominion Chemist, Year Ending March 31, 1925, 67, 1926. From Chem. Abst., **21**: 618, February 20, 1927. Analytical data tabulated for waters from 34 Canadian hatcheries.—*R. E. Thompson.*

Water Filtration. M. J. MARTIN. Chem. Eng. Mining Rev., **18**: 503–5; **19**: 29–32, 1926. From Chem. Abst., **21**: 618, February 20, 1927. General description of slow sand and mechanical water filtration given. Rates of filtration, comparison of efficiency, methods of testing operating efficiency, and use of coagulants described.—*R. E. Thompson.*

Pressure Filtration Plant at Thornton. Water and Water Eng., **28**: 459–62, 1926. From Chem. Abst., **21**: 618, February 20, 1927. Sixteen pressure filters 8 feet in diameter, giving total filtering area of 800 square feet, are used because of their efficiency in removing peaty discoloration. Water is treated with aluminum sulfate and lime to neutralize acidity.—*R. E. Thompson.*

Corrosion of Water Mains. H. E. BELLANY. Commonwealth Eng., **14**: 149–52, 1926. From Chem. Abst., **21**: 618, February 20, 1927. Two chief theories of rusting are the carbonic acid theory and the electrolytic theory. Moisture is necessary. External corrosion may be promoted by minute amounts of soluble salts in wet soils. Cast iron, owing to its greater thickness, has the advantage over steel pipe. Corrosion may be prevented by increasing skin resistance of cast iron, utilizing preventive influence of alkalies by surrounding pipes with lime or cement where practical, excluding acids, salts, or air, and by galvanizing the pipe. Cement lining is most efficient protection known to date.—*R. E. Thompson.*

Loss of Heat Due to the Fouling of Steam Boilers. HELLEMANS. Chimie et industrie, Special No., 300–8, September, 1926. From Chem. Abst., **21**: 618, February 20, 1927. Shown both by theoretical calculations and by results of comparative boiler tests that reduction in fuel consumption generally claimed by manufacturers of water softening equipment or boiler compounds is greatly exaggerated. Removal of soot and ashes from tubes increase boiler efficiency about 3 per cent, while removal of scale (varying from 0.75 to 12 mm. in different parts of boiler) had no appreciable effect.—*R. E. Thompson.*

The Control of Flue Gases by Means of Carbon Dioxide Recorders. JULIUS GRANT. Ind. Chemist, **2**: 433–6, 1926. From Chem. Abst., **21**: 641, February 20, 1927. In general practice best working conditions result when 12–14 per cent carbon dioxide is present in flue gases. With powdered fuel and oil this may rise to 19 per cent. Following instruments described: (1) "Akron" carbon dioxide recorder, (2) "Carbon Dioxide Thermoscope" (Underfeed Stoker Co.), (3) "Ranarex" recorder, (4) Cambridge Instrument Co.'s thermal conductivity instrument. Brief account of several other instruments included.—*R. E. Thompson.*

Hard Water and Its Effect on the Scouring and Dyeing of Cotton and Wool Unions. M. G. MORRIS. Am. Dyestuff Rept., 15: 845–6, 892. 1926. From Chem. Abst., 21: 652, February 20, 1927. Where hard water only is available, softening compounds must be added to the washer and the goods allowed to run in this softening bath before any soap is allowed to come in contact with fabric.—*R. E. Thompson.*

Apparatus for Reconditioning Zeolite Water Softeners. W. J. KENNEY. U. S. 1,617,288, February 8, From Chem. Abst., 21: 974, March 10, 1927.—*R. E. Thompson.*

Lye Concentrations in Boiler Plate Seams. R. BAUMANN. Arch. Wärmewirtschaft, 7: 255–60, 1926. From Chem. Abst., 20: 3762, November 20, 1926. To test theory that many failures of boilers are due to embrittling action of strong caustic solutions accumulating in seams, an artificial seam was prepared in bottom of small boiler in which 1 per cent sodium hydroxide was boiled. Under no condition of rate or time of boiling, width or shape of crack, or tightness of seam was concentration of liquid in crack as high as 3 per cent. Material in seams of boilers in use was found to be ordinary scale, with no unusual alkali content.—*R. E. Thompson.*

Preparation of Feed Water for Steam Boilers by Evaporators. WINTERMEYER. Feuerungstechnik, 14: 263–6, 1926. From Chem. Abst., 20: 3762, November 20, 1926. Review of advantages of feeding of boilers with distilled water, and of methods and apparatus for providing it.—*R. E. Thompson.*

Effect of Chlorine on the Absorption of Dissolved Oxygen by Polluted Waters. P. GAUNT and W. E. ABBOT. J. Soc. Chem. Ind., 45: 323–4T, 1926. From Chem. Abst., 20: 3763, November 20, 1926. Chlorine reduces absorption of dissolved oxygen. Increased dilutions cause effect to disappear. Recommended that effluents might be chlorinated where dissolved oxygen of diluting water is not sufficient to take care of effluents.—*R. E. Thompson.*

Experiences with Chlorine Treatment of Water and Sewage. G. ORNSTEIN. Z. angew. Chem., 39: 1035–7, 1926. From Chem. Abst., 20: 3764, November 20, 1926. Chlorination of raw water at Hamburg to kill algae reduced filter washing 75 per cent. Dosage was 1.5 p.p.m., slight additional amount being applied to filter water. Chloramines increase effectiveness of chlorine treatment.—*R. E. Thompson.*

Chemical Characteristics of Some Trade Wastes. A. M. BUSWELL, R. E. GREENFIELD and A. R. SHIVE. Ind. Eng. Chem., 18: 1082, 1926. From Chem. Abst., 20: 3765, November 20, 1926. Analyses of wastes from pea and corn canneries, strawboard, paper, and roofing factories and distilleries given.—*R. E. Thompson.*

Disposal of Some Organic Trade Wastes. EDWARD BARTOW. Ind. Eng. Chem., 18: 1085, 1926. From Chem. Abst., 20: 3765, November 20, 1926.

Dried packing house sludge contains 6–8 per cent nitrogen, but no satisfactory method has been found for dewatering it. Potassium chloride, sulfate, and nitrate, betaine-hydrochloride, and glutamic acid have been made or recovered from beet-sugar wastes. Waste utilization in starch factories has reduced organic content of effluents in some cases to less than 0.5 per cent of corn used.—*R. E. Thompson.*

The Girard, Ohio, Water-Softening Plant. American City, **38**: 3, March, 1928. The raw water, collected from an abandoned coal mine, is hard and has a high iron content. The 1-m.g.d. plant consists of mechanical mixing basins, settling basins, recarbonation chamber, two filter beds, and a clear well. The four mechanical mixing basins provide a detention period of 30 minutes, and the paddles rotate at 3 r.p.m. Detention period in settling basins is 3½ hours. The two recarbonation chambers 9 feet 3 inches by 10 feet 9 inches by 12 feet 6 inches deep, are equipped with pipe grids with 64 ⅛-inch holes for the distribution of the CO_2. The CO_2 plant consists of coal crusher, magnetic iron separator, conveyor, and combined pulverizer and blower that delivers powdered coal to a furnace. The products of combustion are washed, dried, and then forced to a gas receiver. The plant produces 21 pounds CO_2 per hour. An excess of 2.0 p.p.m. CO_2 is present in the filtered water. The effluent does not have to be chlorinated.—*C. R. Cox.*

Who Should Own the Water Meters? American City, **38**: 3, March, 1928. A tabulation based upon a survey of 3,282 cities throughout the country, in which 1,764 reported ownership of meters by cities, 682 by private water companies and 836 by the consumers. The opinions of 20 consulting engineers upon the subject are given, from which it appears that the majority are in favor of the municipality or company owning the meters. There are many aspects, however, to the problem.—*C. R. Cox.*

Iron and Manganese Removal at Wausau, Wis. Emil Flatter. American City, **38**: 3, 125–126, March, 1928. A description of a 3–4.5 m.g. iron and manganese removal plant, costing $125,000. Well water of poor physical character is being effectively treated by aëration, coagulation and sedimentation, and filtration. Final chlorination is not needed. The aërator consists of shallow wooden racks, holding 5-inch layers of coke and 2-inch layers of manganese dioxide ore, which are arranged in vertical tiers. The aërated water is dosed with 7.4 g.p.g. alum and 3.5 g.p.g. lime before discharge through a baffled mixing chamber into a 45 x 45 x 16 feet Dorr clarifier, and then into three sedimentation basins, each 36 x 45 x 14 feet in size. Six rapid sand filters are fitted with porous concrete slab underdrains capable of passing 150 g.p.m. per square foot. Slabs are bolted to concrete stringers and have joints cemented. Slabs were made of ¾- to 1-inch gravel. A gravel layer of this size is used over slabs to depth of 6½ inches, then of ⅜- to ½-inch size to depth of 3 inches, and then of $\frac{1}{16}$- to ⅛-inch size to depth of 3 inches. Fine sand to depth of 28 inches is placed upon gravel. Complete control and recording apparatus is provided. From 2½ to 3 per cent wash water is used, which is somewhat high because considerable fine floc reaches the filters.—*C. R. Cox.*

Modern Equipment in Meriden, Conn., Filtration. C. PERRY PRANN. Water Works, 66: 507–9. 1927. The new filtration plant for the Broad Brook supply will have a capacity of 5 million gallons per day and will consist of an aërator, two coagulation basins, pump room, chemical room, six sand filters, two filtered water storage wells, and chlorinating equipment. The chemical solutions are to be introduced into the water by automatic proportionate feeders at the throat of a Venturi tube.—*C. C. Ruchhoft.*

Temperatures in Denver Reservoirs. IVAN E. HOUK. Public Works, 58: 405–9. 1927. Temperature measurements at various depths and comparisons with air temperatures were made on two of Denver's reservoirs. The summer stagnation period continued from April until September. Dissolved oxygen studies showed that the water at a depth of 45 feet usually contained less oxygen than the surface water. During the summer time the water at 45 feet was usually less than 50 per cent satuarted with oxygen.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Flow of Mud Through Pipe. AUGUST V. GRAF. Water Works, 66: 488. 1927. The relationship between the head and the discharge of a mud of 35 per cent solid content was studied for various diameters and lengths of brass pipes. It was found that at first with the head increasing the velocity changed very slightly until a point is reached where the law is abruptly changed to fit the formula of Poiseuille for the viscous or straight line flow of fluids.—*C. C. Ruchhoft.*

Garden Hose Water. J. B. MARCELLUS. Water Works, 66: 492. 1927. Data on the discharge of water through ¾-inch garden hose of 50-, 100-, and 150-foot lengths at pressures from 10 to 55 pounds. On the 50-foot open hose the discharge varied from 3.68 gallons per minute at 10 pounds to 8.52 at 50 pounds.—*C. C. Ruchhoft.*

Municipal Water and Sewerage Costs in Maryland. ABEL WOLMAN. Jour. New Engl. Water Works Assoc., 41: 4, 439, December, 1927. There are many different methods of financing municipal public utilities. In established communities financing must follow old familiar lines, which, although they are often the results of historical accidents, are accepted by average citizens as logical means. These methods arose out of (1) historical accident and precedent, (2) concessions to political expediency, (3) efforts to meet psychologies peculiar to each locality, (4) and in a few instances the desire to follow a logical procedure. Primary principles for a plan to meet both capital and operating costs of water and sewerage systems should (1) separate public and private benefits and (2) differentiate completely between fixed and operating charges. In Maryland, a combination of general property tax, annual front-foot assessment during terms of bonds issued, cash payment for house connections, meter service charge, and water consumption charge has been used to provide for installation of water supply and sewerage systems. Charges were distributed between various classes of benefits. The procedure of financing water-main and sewer-line construction by the front-foot assessment has been quite suc-

cessful in Maryland. Regardless of the sytem of payment in use the total annual cost to the consumer is lower than for practically any other commodity. Opportunities for inequality in distribution of the burdens of taxation are possible and do exist. In the event of legal dispute over taxes on grounds that the territory is not benefited the courts have upheld that if legislation has fixed the district and laid the tax for it, then, in the opinion of the legislative body, such a district is benefited.—*Carl Speer, Jr.*

Pipe Welding and Other Recent Developments in Welding. D. H. DEYOE. Jour. New Engl. Water Works Assoc., **42**: 1, 25, March, 1928. A few of the recent developments in welding are given together with their uses and advantages, and results. Types discussed are (1) arc-welded metal railroad ties, (2) metallurgical study of steel plate and electrode material, (3) replacement of castings by welded steel plate, (4) pipe welding.—*Carl Speer, Jr.*

Thermit Pipe-Welding. ROBERT L. BROWNE. Jour. New Engl. Water Works Assoc., **42**: 1, 21, March, 1928. Thermit process was perfected in Germany for reduction of pure metals from their oxides. Iron thermit, used for welding purposes, is a mixture of finely divided aluminum and iron oxide. Fundamental principle is: aluminum burning, with the oxygen of iron oxide sustaining combustion. Initial temperature (2800°F.) to start aluminum burning is obtained by a small quantity of ignition powder placed in a crucible on top of thermit and ignited with a match. The aluminum combines with the oxygen of the iron oxide forming aluminum oxide (slag) setting the iron free. Temperature of this reaction (5000°F.). Thermit is used as a heating agent to bring the pipe ends to a welding temperature. They are then forced together, making a forged weld and a permanent non-leaking union. After weld is completed the thermit steel and slag are discarded. This method is most commonly used with standards, with extra-heavy pipe-up to and including 6-inch, and with double extra-heavy pipe up to and including 4-inch. Actual steps in welding process are given. Operation is simple and more or less mechanical which makes it practically fool-proof and assures uniform results. This together with portability of apparatus and absence of need for outside source of power makes for rapid and economical production.—*Carl Speer, Jr.*

Pipe-Line Welding from the Oxy-Acetylene Viewpoint. LEROY EDWARDS. Jour. New Engl. Water Works Assoc., **42**: 1, 3, March, 1928. Advantages of oxy-acetylene welding are (1) permanence of joint; a welded joint is of same material as pipe. (2) tightness under high pressures, which facilitates transfer of liquids and gases. (3) economy; leaks can be repaired in place without taking line apart. (4) resistance to the stresses of expansion and contraction due to temperature changes. (5) sufficient flexibility to follow contour of ground surface. (6) giving steady employment to a trained group of men in making up stock fittings during seasons when out-door construction is impossible; this saves expense of labor turn-over and high wages to seasonal labor. Each joint should pass a good field test and a tensile test. Equipment should be standard. To insure perfect welds pipes should be properly aligned. Various methods of supporting the pipe and lowering it into the trench are

given. Pressure test is required. Ends of pipe are closed and pressure administered for this test.—*Carl Speer, Jr.*

Heading Off Sand and Ice Troubles. JEAN JACQUES. Water Works Eng., 81: 3, 139, February 1, 1928. Canon City, Col., protected water intakes from ice by constructing an "ice boom" with a skimming rudder. Ice stopped by this device was held in subjection in the current and carried on over the dam. Trouble also occurred from sand getting past the intake valves and clogging the line to such an extent as to materially reduce its carrying capacity. Instead of endeavoring to quiet the water, as was done with the ice, the water was agitated to force the sand out into the current away from the intakes. Three booms, similar to ice boom, are in automatic operation. They are placed behind and below the ice boom and run at a forty-five degree angle to the river.—*Carl Speer, Jr.*

Avoiding Pollution by Coke Oven Wastes. HUGH E. JONES. Water Works Eng., 81: 3, 141, February 1, 1928. All phenols, when chlorinated, make water unpalatable. Attention has been directed to the removal of phenols from ammonia liquor before it was treated in the lime still, and two successful methods have been evolved namely, the benzol extraction method, and the patented Tiddy-Heffner, or distillation method. Author gives description of benzol extraction method plant constructed by the Domestic Coke Corporation at Fairmont, W. Va. The extraction efficiency of this plant is about 96 per cent. Plant under normal operation treats 36,000 gallons of ammonia liquor per day and is operated about 12 days a month. It recovers more than 25,000 gallons of crude phenol per year and is financially self supporting.—*Carl Speer, Jr.*

What is the Best Rate of Filtration? R. B. SIMMS. Water Works Eng., 81: 1, 19, January 4, 1928. Rate generally used in design of rapid sand filtration plant is two gallons per minute per square foot of sand area. Initial loss of head should usually be from 1½ to 2 feet in order that sufficient resistance be presented to passage of water to obtain filtering action. Rate of wash water generally used is 15 gallons per minute per square foot of sand area or 24 inches vertical rise per minute. Usual length of wash is from 5 to 6 minutes although at times longer periods may be necessary. Amount of wash water used should be less than five per cent of water filtered.—*Carl Speer, Jr.*

Park the Water Works Grounds? Yes! J. D. FOWLER. Water Works Eng., 81: 1, 13, January 4, 1928. Water Works grounds should be beautified for psychological reasons. Beautiful things, or surroundings, suggest purity. Author shows practical advantages of beautification. Describes driveways, walks and paths, shrubbery, lawns, flower beds, and other decorative auxiliaries.—*Carl Speer, Jr.*

Historic Review of the Development of Sanitary Engineering in the United States during the Past One Hundred and Fifty Years. A Symposium. Discussion. Proc. Am. Soc. Civ. Eng., 53: 10, 2743–70, December, 1927. J. W.

ARMSTRONG. Bituminous enamels make excellent waterproof coatings for both iron and concrete. A thin coating of lime has deposited on the inside of pipes at New Orleans and gives good protection. At Baltimore, where the water is naturally corrosive, sufficient lime is added to maintain a pH of about 8.2. Centrifugal pumps are low in first cost, require very little repair work, and require very little labor to operate. The filter plant at Little Falls, N. J., was the first to be constructed entirely of reinforced concrete. J. W. ELLMS. Progress during the past half century in the water-works field has been due to the labor of many individuals and associated groups. C. M. SAVILLE. The largest increase in the construction of public water supplies came after 1880. The use of house cisterns or tanks in connection with the public supply was once a very common mode of supply for buildings. Wooden pipes of bored logs were used in many localities. A 30-inch cement lined pipe installed in 1871 for the old Charlestown, Mass., Water-Works is still in service. There has been a vast improvement in the matter of providing adequate fire protection. Slow sand filters are usually more economical than rapid sand, but are applicable only to certain waters. W. KIERSTED. Discusses what may be accomplished by sedimentation in water purification and sewage disposal. Sedimentation is of more importance than filtration. M. M. O'SHAUGHNESSY. Mentions a few points overlooked by Mr. FULLER. J. H. GREGORY. Where the combined system of sewers is used, storm overflow may be of considerable importance if the streams are small. K. IMHOFF. Discusses briefly conditions most suitable for sludge digestion. K. ALLEN. A brief history of the development of sewers and sewage disposal is given. L. L. TRIBUS, A. E. MORGAN, A. M. SHAW, W. B. GREGORY, H. F. GRAY, T. LEWIS, and S. R. LEWIS. These authors discuss the disposal of municipal refuse, drainage, and ventilation.—*John R. Baylis.*

New Theory for the Centrifugal Pump. A. F. SHERZER. **Discussion.** Proc. Am. Soc. Civ. Eng., 53: 10, 2771–8, December, 1927. J. W. MACMEEKEN. The author does not agree with Mr. SHERZER that mathematical facts should be replaced by rational reasoning. One pump built in Europe gave a total head of $\frac{0.96\ V_2^2}{g}$ at shut-off and practically the same at designed conditions. Such pumps are costly to construct and are not suitable for the competitive field. Pumps with a concentric case will require a greater impeller diameter than that required for the volute pump of good design. T. KINGSFORD. Several pumps checked against the principles given in the paper agree substantially with the results given by Mr. SHERZER. S. A. MOSS. The fundamental equations, as usually given, are correct. P. L. REED. The accepted theory of velocity head is too well grounded in the laws of mechanics to be overthrown. A number of Mr. SHERZER's original mathematical derivations and conclusions are unsound.—*John R. Baylis.*

Determination of the Caustic Value of Lime. (Two Filtration Devices.) W. W. SHAW, W. H. MACINTIRE, and J. E. UNDERWOOD. Ind. Eng. Chem., 20: 312–4, 1928. Two forms of filtering apparatus are described which are applicable for use in either the sugar or Scaife method of lime analysis. Cuts

are given. It is pointed out that the present Scaife method is accurate for the clear solution obtained from high calcium limes but is in error when used to obtain results with high magnesium limes due to the resultant precipitate being difficult to settle. It is believed that the Underwood device is the most practical for use. Results using either form of apparatus compared with those obtained by the existing sugar or Scaife methods are in close agreement.—*Edward S. Hopkins.*

Effect of Certain Impurities upon the Determination of Causticity of Limes by Modifications of the Sugar and Scaife Methods. W. M. SHAW and W. H. MACINTIRE. Ind. Eng. Chem., **20**: 315–9, 1928. This study presents the influence of impurities in lime upon the accuracy of the modified sugar and Scaife methods of analysis previously described. Chemically pure substances were used and the lime usually manufactured in the laboratory. The effects of high magnesium, excess silica, addition of silica gel to the hydrochloric acid solution of the Scaife method, calcium silicate impurity, and calcium aluminate were studied. The modified form of analysis compares very well with the usual methods and should be of value.—*Edward S. Hopkins.*

Is the Statistical Method Applicable to the Bacterial Plate Count? C. S. MUDGE and B. M. LAWLER. Jour. Bact., **15**: 207–21, 1928. "This paper is frankly critical, its object is to point constructively to consequences of too close adherence to a mathematical formula." The results obtained are based upon a study of bacterial counts upon milk, but the conclusion drawn, that statistical averages are subject to serious error in interpretation of results, is of value in water bacteriology. Tables and detailed description of manipulation are given.—*Edward S. Hopkins.*

Algae-Methods of Eliminating Tastes and Odors. CHESTER COHEN. Southwest Water Works Jour., **10**: 9–10, April 28, 1928. A brief discussion of tastes and odors caused by algae growths and of methods of control. Small tanks should be covered. Copper sulphate usual algicide employed. Chlorine possesses certain advantages over copper sulphate.—*John H. O'Neill.*

Elimination of Errors in the Orthotolidin Method. F. R. MCCRUMB. Southwest Water Works Jour., **10**: 1, 11–15, April 28, 1928. The orthotolidin test is not specific for chlorine but appears to be an oxidation reaction. Iron, manganese, and nitrates interfere. A modified test using a color comparator is described which gives reasonably accurate tests over a range of 0.1 to 10 p.p.m. when solution contains above substances, or color, or turbidity. The pH affects test. Method is given for preparing orthotolidin reagent. List of references is appended.—*John H. O'Neill.*

A New System of Fluid Measurement Control, Indication, Integration, and Recording. C. ARTHUR BROWN. Southwest Water Works Jour., **10**: 1, 27, April 28, 1928. Describes the principle on which is based design of a magnetic clutch gulp meter which measures small flows with an accuracy of 98 per cent, or better, over a range of from less than one-half gallon per hour to

more than 1,000 gallons per hour, and has a range of accurate registration from 30 to 60 times that of best existing meters.—*John H. O'Neill.*

Various Uses of Chlorine. Clyde C. Hayes. Southwest Water Works Jour., **10**: 1, 28, April 28, 1928.—*John H. O'Neill.*

Cross Connections Held Responsible for Three Typhoid Outbreaks. Public Health Reports, **42**: 49, 3022, December 9, 1927. Typhoid outbreaks occurred in Cohoes, Albany, and Oswego, New York. Each outbreak was directly traceable to cross connections. Upon elimination of the latter, prompt improvement in the sanitary quality of the water followed.—*R. E. Noble.*

Court Decisions Relating to Public Health. Town Held Liable for Sewage Pollution of Stream. Public Health Reports, **43**: 3, 123, January 20, 1928. Iowa Supreme Court; Stovern *vs.* Town of Calmar, Winneshiek County, 216 N. W. 112; decided November 22, 1927. **Ordinance for Prevention of Pollution of Source of City's Water Supply, Located in United States Forest Reservation, Held Invalid.** Public Health Reports, **43**: 3, 124, January 20, 1928. Washington Supreme Court; Brown *vs.* City of Cle Elum, 261 P. 112; decided November 23, 1927. **Operation of Swimming Pool Enjoined to Prevent Pollution of City Water Supply.** Public Health Reports, **43**: 5, 270, February 3, 1928. Texas Court of Civil Appeals; Newton et al. *vs.* City of Groesbeck, 299 S. W. 518; decided October 6, 1927.—*R. E. Noble.*

Phenol Recovery Plant Avoids Waste Pollution of Streams. H. E. Jones. Chem. & Met. Eng., **35**: 215–8, April, 1928. Phenol is removed from the ammonia liquors of the Domestic Coke Corporation at Fairmont, W. Va., by extraction with benzol. The crude ammonia liquor is supplied to the top of an absorption tower 6 feet in diameter and 36 feet high, passes downward through the tower, and then to the top and down through another tower 34 feet high. The benzol is passed through the absorbers in the direction opposite to the flow of the ammonia liquor, the fresh benzol coming in contact with the ammonia liquor containing the least phenol. A recovery of 96 per cent of the phenol is accomplished. The benzol is stripped of phenol by washing with a caustic soda solution, producing sodium phenolate which, upon acidification, yields a marketable crude phenol.—*John R. Baylis.*

Water Softening with Barium Salts. C. J. Rodman. Chem. & Met. Eng., **35**: 221–3, April, 1928. Operating data on the use of lime-barium water softeners are given. $BaSO_4$ passes through the colloidal state and is not easily filtered unless precipitated by some electrolyte. With 15 grains per gallon of SO_4 in the Mahoning River water it was impossible to remove more than 85 per cent of the calcium sulfate from pure solutions by barium carbonate. The reaction was improved in the presence of small quantities of $Ca(OH)_2$, due to the formation of some $Ba(OH)_2$. Elimination of all the $CaSO_4$ was accomplished when Na_2SO_4 and NaCl were present in small quantities. The barium treatment eliminates foaming and priming troubles.—*John R. Baylis.*

Chemical Engineering Applied in New St. Louis Water Plant. C. W. CUNO. Chem. & Met. Eng., 35: 230–1, April, 1928. The entrance of chemical engineering into its own has never been more apparent than at the new plant of the St. Louis water service now being completed on the Missouri River. The water, which is quite turbid, will pass through primary Dorr clarifiers, a mixing conduit, mixing tanks, secondary Dorr clarifiers, settling basins of about 13 hours detention period, a carbon dioxide chamber, a second rapid mixing conduit, a secondary coagulating chamber, and then to the filters. Lime will be added to the water as it enters the first mixing conduit and sulfate of iron as it leaves. It is expected that the turbidity of the water leaving the settling basins will not exceed 5 parts per million. The carbon dioxide will be obtained from the boiler-house flue gas, burning bituminous coal. Aluminum sulfate will be added to the water as it enters the second rapid mixing conduit and chlorine will be added to the effluent from the filters. The plant will have a daily capacity of eighty million gallons.—*John R. Baylis.*

Water Works Committee Report. Proc. Am. Soc. Munic. Improvements, 33: 185–9, 1927–1928. The report briefly summarizes a few matters of interest in the water works field.—*John R. Baylis.*

Planktology. JOHN B. HAWLEY. Proc. Am. Soc. Munic. Improvements, 33: 189–90, 1927–1928. Air-borne organisms were studied. A sterilized glass dish was filled with distilled water and Knop's plant food added. After a month's exposure to the outside air, protozoa, algae, and other organisms were found.—*John R. Baylis.*

Chlorination of Water Supply of Chicago. A. E. GORMAN. Proc. Am. Soc. Munic. Improvements, 33: 191–6, 1927–1928. The chief pollution of the water at the Chicago intakes is shore pollution driven to the intakes by wind. Automatic devices have been installed in the Chicago and Calumet Rivers to indicate when there is a reversal of the flow towards the lake. The water is being chlorinated at the 10 pumping stations. The chlorinating equipment at each station is in duplicate and is set in duplicate booths. The equipment in each booth is capable of delivering 6.5 pounds of chlorine per million gallons of water, based on maximum pumpage. A chlorine manual, which covers all features of chlorination practice in Chicago, was prepared and printed copies supplied all employees concerned. Hourly residual chlorine tests are made and have been useful in giving warning of the arrival of polluted water. Two pounds of residual chlorine is maintained in the water as it leaves the pumping stations. During 1926 there were 47 periods of high chlorine absorption, the longest being 24 consecutive hours. The approximate cost of chlorination is about $175,000 per year.—*John R. Baylis.*

Results of Water Waste Survey. L. A. QUIGLEY. Proc. Am. Soc. Munic. Improvements, 33: 205–7, 1927–1928. A brief summary of the leaks found in the water system of Ft. Worth is given.—*John R. Baylis.*

Cast Iron Water Pipe. L. A. LONG. Proc. Am. Soc. Munic. Improvements, 33: 209–10, 1927–1928. The author gives a brief history of the first water pipes used and the latest step in the manufacture of cast iron pipe.—*John R. Baylis.*

Use of Two Mains in Wide Streets. T. F. WOLFE. Proc. Am. Soc. Munic. Improvements, 33: 211–21, 1927–1928. The trend is towards the use of two mains in wide streets: each main being installed between the curb and the sidewalk. The advantages of two mains are:—lower first cost in wide streets, lower maintenance cost, services not installed until needed, no dead services, no trenching beneath proposed pavements, no tearing up of pavements, additional main capacity, and better fire protection. Diagrams illustrating how the mains may be installed are given.—*John R. Baylis.*

ABSTRACTS, SUB-COMMITTEE NO. 9

JOINT RESEARCH COMMITTEE ON BOILER FEEDWATER STUDIES

The Boiler Explosion on the Clyde Turbine Steamer King George V. Engineer (Lond.), 145: 3767, March 23, 1928, p. 320. Report of Board of Trade inquiry on accident which took place on September 15th, when, owing to formation of scale on inside of one of the tubes, overheating and consequent rupture took place, which resulted in severe scalding of two of firemen, who later succumbed to their injuries.

Alloy Steel for Boiler Construction. C. MCKNIGHT. Am. Soc. Steel Treating—Trans., 13: 4, April 1928, pp. 638–657 and (discussion) 657–658, 10 figs. As material for boiler construction nickel steel offers following advantages; it is between 25 and 40 per cent stronger than carbon steel with practically same toughness and greater resistance to impact; at boiler temperatures it is much superior to carbon steel; it is immune to aging embrittlement; it can be made to develop even higher strengths than are now demanded; it is resistant to boiler corrosion; it is suited for use as boiler tubes and staybolts. Bibliography.

The Cracking of Boiler Plate. Metallurgist (Supp. to Engineer, Lond.), March 30, 1928, p. 34. Refers to paper by PARR and STRAUB before Am. Soc. Testing Matls., and criticizes their use of term caustic embrittlement as it prejudges case by ascribing cracking definitely to action of caustic soda; conclusions advanced by investigators are important; results are of great interest as affecting ideas of nature of whole process that brings about cracking. See reference to original work in Eng. Index, 1927, p. 101.

Embrittlement of Boiler Plate. S. W. PARR and G. F. STRAUB. Power Plant Eng., 32: 7, April 1, 1928, pp. 414–417. Causes and description of cracks due to embrittlement and methods of inhibition; material has not been found to be at fault; design of boiler is not primary cause; operation is not to blame; sodium hydroxide is only material encountered in boiler which embrittles

stressed steel; increased sulphate has been effective in stopping this trouble; new inhibiting agents have been developed. Abstract of paper presented at Midwest Power Conference.

Boiler Scale And Its Prevention. HERMANN WALDO. Wiss. Veroffentlich. Siemens Konzern **6**: 151–70, 1927. Chem. Abstracts, March 20, 1928, **22**: 1000. The ratios: $CaSO_4/CaCO_3$, SiO_2/CaO, MgO/CaO, as determined by the analysis of boiler-feed water, give an indication as to the nature of the boiler scale that such a water will produce in actual use. These ratios are also determined for the deposited scale. Three kinds of deposits are recognized, namely: hard stones, adherent scales, and mud. The chemical, physical, and electrical methods of preventing boiler scale are discussed. The action of the Cumberland electrolytic method is explained. C. J. B.

Determination of Dissolved Gases in Water (Zur Bestimmung der im Wasser geloesten Gase). H. RICHTER. Chemiker-Zeitung (Koethen, Ger.), **52**: 4, January 14, 1928, p. 47. Samples of water from pressure boilers should be cooled before releasing pressure; boiler water at 138 deg. and 45 atmos. had, after releasing pressure, temperature of 96 deg. and showed no trace of dissolved oxygen; similar sample, cooled to 30 deg. before expansion, showed 0.2 to 0.3 mg. of oxygen per liter.

Boiler Feed-Water Heater With High and Low Temperature Sections, etc. J. D. YODER, U. S. 1,655,033, January 3. Chem. Abstracts, March 20, 1928, **22**: 1002.

The Wyndham Waste-Heat Feed-Water Heating System. Shipbldg. and Shipg. Rec. (Lond.), **31**: 10, March 8, 1928, p. 276, 2 figs. Particulars of system of feed heating, which has recently been patended for use in conjunction with ordinary return-tube type marine boiler, in which heat of flue gases is employed together with heat of auxiliary exhaust steam; using of steering engine and dynamo, feedwater can be raised to temperature of 220 to 230 deg. fahr., at same time making sufficient water in evaporator to maintain boiler supply.

Effect of Bad Condenser Water Conditions. Power Plant Eng., **32**: 7, April 1, 1928, p. 424. Replies with data, in answer to questionnaire sent out by A. S. M. E. Special Research Committee on Condenser Tubes were received from 240 plants; of these only 141 reported failures, and information submitted from 141 plants has been compiled and presented in tabular form.

Determination of the Variations of the Salinity of Estuaries (Les variations de la salinité des estuaires mésurées in situ par la conductibilité électrique). M. and Mme. A. CHAUCHARD. Académie des Sciences—Comptes Rendus (Paris), **183**: 25, December 19, 1928, pp. 1503–1505. Electrolytic method and apparatus for determining degree of salinity of estuary water on site from boat without trouble of raising samples of surface water from some depth.

What Every Engineer and Water-Works Superintendent Should Know about Chlorination. R. V. DONNELLY. New England Water-Works Assn.—Jl., 42: 1, March 1928, pp. 79–90, 3 figs. Chlorine equipment; specifying equipment; common troubles with chlorinators; new uses of chlorine.

Iron and Gas Removal from Industrial Water, Filtration (Déferrisation dégazage des eaux industrielles, filtration). A. LANGUMIER. Arts et Métiers (Paris), 81: 90, March, 1928, pp. 96–109, 1 fig. Purification of water by aëration, by ozone, by chloride of iron; degassing by filtration; kind of filters, sand and mechanical; purification of factory waste water.

Effect of Turbidity on Coagulant Dosage. K. C. ARMSTRONG. Water Works, 66: 12, December 1927, pp. 495–497, 4 figs. Difficulty at Omaha plant in determining correct dosage of coagulants to use; in starting investigation problem was attacked from both chemical and physical side; influence of river turbidity; settling tests of river water; alum dosage and turbidity; some unusual conditions. Results of investigation at filtration plant of Omaha, Neb. Paper presented at Iowa section of American Water Works Assn.

New Filtration Plant at Waukegan, Ill., Designed on Duplex Plan. Mun. News, 74: 3, March 1928, pp. 65–70, 6 figs. Filtration plant and pumping station under construction; duplicate plant; pumping equipment; new type aërators; sedimentation basins; filters; clear wells; chlorination; handling chemicals; plant will have daily pumping capacity of 20 M.G.D. and filtered water-storage reservoir capacity of 4,300,000 gal.

One Year's Operation of the St. Catharine's Filter Plant. A. MILNE. Contract Rec. (Toronto), 42: 11, March 14, 1928, pp. 295–297, 5 figs. Operating staff; plant operation is performed by four men; unusual turbidity conditions; total amount of water filtered during year was 1,722,890,000 imperial gallons; tests and records; operating costs; cost of production per million gallons works out at $16.57 at rate filtered.

Corrosion of Iron Water Pipes and Methods of Treating Water to Reduce Corrosion. J. R. BAYLIS. Baltimore Engr., 11: 12, March 1928, pp. 6–10, 2 figs. Electrochemical theory of corrosion; definition of hydrogen ions; factors influencing corrosion of iron; characteristics of iron rust; proper treatment of water to prevent corrosion.

Hardness—Its Effects and Removal. R. E. THOMPSON. Can. Engr., 54: 11, March 13, 1928, pp. 115–116 and 126. Brief review of temporary and permanent hardness in water, and discussion of methods of correction; effects of hardness; softening by base exchange; lime-zeolite method. Paper read before Can. Sec., Am. Water Works Assn.

Water Softening at Oberlin, Ohio. W. H. CHAPIN. Water Works, 66: 12, December 1927, pp. 481–482, 2 figs. How long storage obviated after-precipitation; mechanism of treatment at Oberlin; use of alum; effect of sand filtration on stored water. Abstracted from Indus. & Eng. Chem.

Abolition of Cross-Connections Causes Lively Discussion. Eng. News-Rec., **100**: 12, March 22, 1928, pp. 488–490. Pollution of municipal water supplies through cross-connections to non-potable sources of supply used for industrial purposes or fire protection have caused action designed to outlaw such connections; Abstract of report of committee to New England Water Works Assn.

Treatment of Pure Water Without Distillation—Electro-osmotic Process (Préparation d'eau pure sans distillation: l'électro-osmose). P. PATIN. Chimie et Industrie (Paris), **19**: 2, February 1928, pp. 205–213, 10 figs. Problem of pure water; electro-osmosis in general; electro-osmotic cells and apparatus and details of construction; utilization of cathodic water; production cost of pure water.

NEW BOOKS

Report of Bureau of Sanitary Engineering, Maryland State Department of Health, 1927. ABEL WOLMAN. 21 pp. (1928). Review of extensive activities of Bureau in 1927 is admirably presented. Total value of work represented by plans submitted for approval was $7,600,000. At last session of Legislature bonds for public health engineering work to the value of $22,297,000 were authorized. One of the most important sanitary acts of Legislature, sponsored for a number of years by the Bureau, provides authorization to any county or municipality to submit to referendum at any regular election the question of issuing bonds for water or sewerage systems to extent of 5 per cent of taxable value without individual legislative permission in each case. Extensive studies were carried out on the treatment of industrial wastes. Good clarification of tannery wastes which had been passed through screens and a Dorr clarifier was obtained by treatment in a fill-and-draw tank with lime and ferrous sulfate. Somewhat over 100 grains per gallon of each coagulant was needed to produce satisfactorily clear, but tea colored, supernatant. Further treatment with iron rendered effluent water white, but this was considered unnecessary. During past year a waste recovery plant was placed in commission at one paper mill consisting of 2 large receiving basins, 6 coagulation basins, alum machine, centrifuge and sludge lagoon. Water over and above that returned from receiving basins for reuse in plant is treated with alum and allowed to settle approximately 3 hours. Good clarification is obtained with 133–141 grains per gallon of alum. The total volume of wastes and of solids respectively discharged into stream from this plant have been reduced from 1,700,000 gallons and 7 tons to 130,000 gallons and 0.18 ton per day. Until such time as actual efficiency and proper method of operating centrifuge have been determined the sludge will be discharged directly into lagoons. As result of a law suit one laundry in state has been treating waste with iron and lime at rate of 35 and 105 grains per gallon respectively before discharging into stream. As effluent was unsatisfactory a large cinder and gravel oxidizing bed has been installed which effects excellent clarification. Effluent from bed contains twice as much dissolved oxygen as the tank effluent. It is proposed to convert existing tank into mixing tank and construct new sub-

sidence tank, as present mixing is totally inadequate and is probably wasteful of chemicals. Activities in connection with waste from the garbage reduction plant were continued in 1927, including treatment of liquid waste in thickners and treatment of sludge from subsidence in centrifuges. Latter resulted in considerable recovery of grease. Pollution with sulfuric acid and ferrous sulfate from steel mills also received attention. At one mill installation of recovery plant was considered too costly, but as result of studies suggested by Bureau the amount of acid used per ton of product has been reduced 50 per cent. Experiments on treatment of tomato cannery wastes showed that satisfactory clarification can be secured if chemicals are thoroughly mixed with waste and latter allowed to remain quiescent for at least 2 hours. Well clarified effluent was obtained with application of 6 grains ferrous sulfate and 4 grains lime per gallon, but decolorization was not entirely satisfactory. Effluent was highly putrescible, indicating need of further oxidation. An investigation was carried out in connection with pollution of tap water of Consumers Ice Plant at Crisfield. Portion of town is on made ground and rise and fall of tide water takes place as in adjacent tidal water. It was concluded that as each house connection was furnished with bleeder valves to shut off water at night to prevent freezing, and also to prevent excessive loss from leakage at other times, tide water was entering house connections through these valves. Steps were immediately taken to place bleeder valves above high tide water level, following which a large number of samples were collected for examination. In no case have any of town taps shown B. coli presumptives in five 10 cc. quantities since change was made. Experimental work was undertaken to determine proper coagulants to be used at proposed filtration plant at Annapolis. Methods studied were coagulation with alum, sodium aluminate, and alum plus prechlorination. Treatment with alum and sodium aluminate gave better results than alum alone under same conditions. Owing to cost, this treatment could be justified only when raw water contained colloidal clay. Alum treatment preceded by chlorination did not appear to have special value. Sodium silicate containing 15 per cent sodium hydroxide is being experimented with at one institution for prevention of corrosion. Intensive campaign against cross-connections was started in 1927. Approximately 2250 cross-connection were found in Baltimore, of which 40 are relatively serious. Steps are being taken to eliminate these. Considerable attention was given to sanitation of objectionable areas on Gunpowder River watershed. It has been tentatively agreed that cost of providing and maintaining sanitary facilities at more populated areas should be jointly borne by Baltimore City and Baltimore County. The typhoid fever death rate in 1927, 5.7, was lowest in history of state. Exclusive of Baltimore, with rate of 2.0, rate was 9.4. The typhoid data given, which include classification of deaths according to population, indicate clearly that reductions are highly possible and desirable in population groups of less than 1000. Over one-half mortality from typhoid in rural Maryland occurred in those populations having concentration of less than 2500. Assuming value of life to be $5000, and cost of necessary services, together with loss of earning power, to be $500 per case, the savings due to typhoid fever reduction during 1927 alone, as compared with average for 1911, 1912 and 1913, would equal $3,700,000.—*R. E. Thompson.*

Chemical Character of Waters of Florida. W. D. COLLINS and C. S. HOWARD, U. S. Geological Survey, Water Supply Paper 596-G. The contents of this paper are well indicated by the title. The authors briefly describe the surface characteristics of the State of Florida and then give a short discussion of the geology of the area. The report is concerned only with mineral constituents of various supplies and hence but little reference is made to sanitary quality. A clear cut explanation of the meaning and effect of the various minerals found is given. After explaining the methods of analysis and the expression of results, the State is divided into sections and the surface waters of each generally discussed. Following this there is a very clear and valuable explanation of the requirements for both domestic and industrial waters and brief descriptions of the treatment of ground and surface waters for removing objectionable mineral constituents. Following is a typical analysis as taken from the 14-page table: Starke; municipal supply. 6-inch drilled well, 529 deep, known as "Old well." November 16, 1923.

ANALYST	TOTAL DISSOLVED SOLIDS AT 180° C.	SiO_2	Fe	Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	$CaCO_3$ (Calculated)	No.
Howard	187	23	Tr.	40	12	12	188	8.1	13	Tr.	149	22

—*Arthur P. Miller.*

Notes on Practical Water Analysis. W. D. COLLINS. Water Supply Paper, 596-H, U. S. Geological Survey. In this water supply paper the methods used by the U. S. Geological Survey for analyzing water to determine its suitability for industrial uses are described.

The pamphlet is quite complete and begins with the question of sampling, passing from that into a discussion of reagents and apparatus. In both of these discussions care is taken to point out possible causes of errors.

Unless something is known of the chemical constituents of a water sample a preliminary examination is advantageous. Such an examination indicates the most suitable amount of water to take for evaporation and also includes the final determinations of alkalinity, chloride and nitrate with turbidimetric estimations of sulphate and calcium. Each of these determinations is described in detail.

If the preliminary examination does not give all the information wanted further tests including turbidity, suspended matter, color, precipitated iron, total dissolved solids, loss on ignition, silica, iron, aluminum, calcium, magnesium, sulphate, sodium, potassium and manganese may be run. The procedure in each of these is carefully outlined.

The pamphlet is closed with a discussion of the methods of calculation. Graphic representation of analytical results is also considered.—*Arthur P. Miller.*